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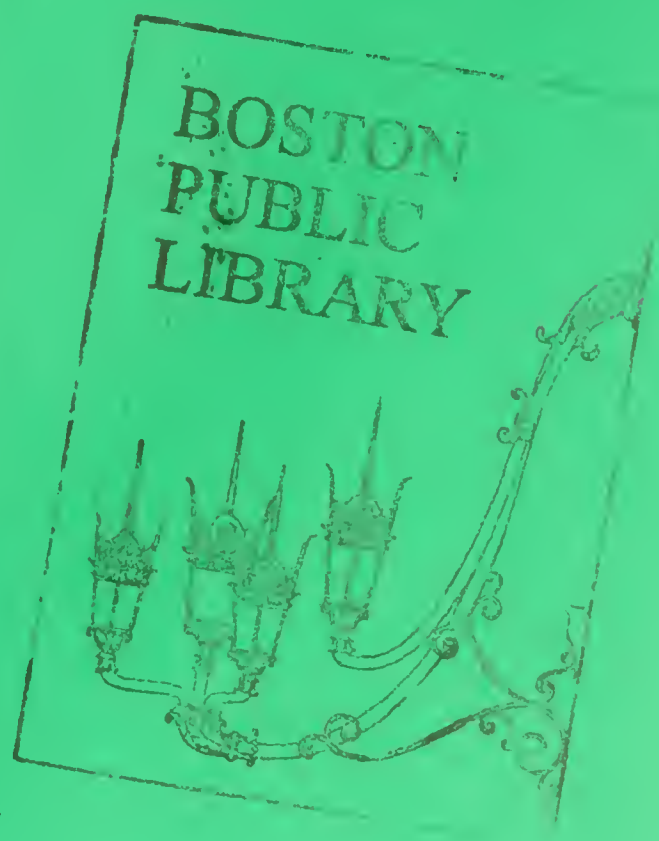
5d. CAPITAL NEEDS DEVELOPED AT THE CORRIDOR LEVEL: CORE & WEST

prepared by
THE EXECUTIVE OFFICE OF TRANSPORTATION & CONSTRUCTION

for presentation to
THE TRANSIT DEVELOPMENT COMMITTEE
of the ADVISORY BOARD to the MBTA

WORKSHOP: APRIL 22, 1976



This document has been prepared as part of the development of the Revised Program for Mass Transportation, 1976. The Staff Reports are prepared with the cooperation of the Central Transportation Planning Staff, The Massachusetts Bay Transportation Authority, and the Advisory Board to the MBTA.

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FREDERICK P. SALVUCCI
SECRETARY

The Commonwealth of Massachusetts

Executive Office of Transportation & Construction
One Ashburton Place
Boston, Massachusetts 02108

MEMORANDUM

TO: Representative James Smith, Chairman April 15, 1976
Advisory Board Transit Development Committee

FROM: Matthew A. Coogan
Director of MBTA Systems Planning

RE: Transmittal of Staff Report #5d

I am pleased to transmit Staff Report #5d--"Capital Needs as Developed at the Corridor Level: The Western Corridor and the Core," prepared for review of the Transit Development Committee. This paper has been prepared for presentation at the Workshop to be held on Thursday April 22 at 4:00 p.m. at the offices of CTPS, 27 School Street, Boston Mass.

The Report was prepared by the EOTC staff, based on a great deal of source material made available by the MBTA, and CTPS. Much of the original work was prepared by CTPS staff for previous TDP efforts. In addition, the Report draws from extensive work accomplished in early phases of the CTPS Framingham-Natick Transportation Study. Other work stems from the MBTA's Central Area Systems Study and BTPR.

Two more PMT workshops are scheduled as follows:

Thursday, April 29, CTPS, 4-6 p.m.--#6: Budget & Priority Issues
Thursday, May 6, CTPS, 4-6 p.m.--#7: Management Policy

We look forward to the active participation of your committee in Workshop #5d.

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STAFF REPORT

52. CAPITAL NEEDS DEVELOPED AT THE CORRIDOR LEVEL: CORE & WEST

SUMMARY

prepared by
THE EXECUTIVE OFFICE OF TRANSPORTATION & CONSTRUCTION

for presentation to
THE TRANSIT DEVELOPMENT COMMITTEE
of the ADVISORY BOARD to the MBTA

WORKING DRAFT - MAY 22, 1976

This document was both prepared as part of the development of the Revised Program for Mass Transportation, 1976. The Staff Reports are prepared with the cooperation of the Central Transportation Planning Staff, the Massachusetts Bay Transportation Authority, and the agencies listed in the parts.

Part One: The Western Corridor

Part One of Staff Report 5d is concerned with the improvement of transportation services in the Western Corridor of the Boston Metropolitan region. Section I of the report presents a brief summary of the demographic make up of the communities, followed by a presentation of the PMT Origin-Destination tables for the corridor. The demographic information, which is presented for each city and town in the corridor, shows the marked variation in population growth rates for the period between 1960 and 1975. In the innner areas, such as Newton and Brookline, the population has been somewhat stable, with declines of 3% and 2% respectively. In the same period the further communities of Sudbury and Holliston, for example, experienced growth rates of more than 100%. As a whole, the corridor outside of Rte 128 is forecast to experience a growth rate of 16.7% between 1970 and 1980. This is slightly higher than the outer North Shore sector, but less than the other far suburban sectors.

Travel data is presented in Section I to describe the trip making characteristics of the inner Green line communities. Because of the level of disaggregated detail desired, and because of severe problems with more recent data,(such as the 1970 census,) detailed trip making data for the inner neighborhoods is presented directly from the major 1963 survey of the EMRPP. This data shows the relative level of of downtown tripmaking orientation for the separate communities, the level of absolute magnitude of transit trips, and the 'mode split' or percent to transit for each of the areas. The data shows that the communities directly served by the Green line Beacon and Commonwealth lines (and by the Watertown line at the time of the survey) have exceptional levels of downtown orientation. Some 45% of the AM peak period trips from North Brookline have their destinations in the CBD and the Kenmore/Fenway areas of Boston. In terms of their mode split, however, the areas tend to be somewhat lower than the close-in areas served by the Rapid Transit mode. North Brookline, for example, has a peak period mode split of 53%, compared with over 80% for East Boston.

An inventory of existing services is presented in Section II of the Western Corridor report, followed by a description of the socio-economic characteristics of the riders of the Green Line, the MBTA express bus, the private carrier bus, and the commuter rail services. The probable inter-relationship between transit services and household characteristics is noted for the inner Green Line neighborhoods. Section II also presents a brief summary description of the functions of the total Green line system. It is shown that it is inaccurate to think of the Green line as a traditional radial transit facility. Rather, the Green line is shown to be the principal regional distributor for trips from all corridors to a set of growing destinations in the expanded core.

Section III of the report summarizes the intense program of investment that has been occurring in the Wester Corridor over the last five years. The Report reviews the 1966 PMT's plan to convert the Riverside line to high platform operation at some uncertain point in the future, with the concomittant recommendation that a full fleet of new Green Line vehicles not be purchased. Section III reviews the modification of that policy which culminated with the publication of the Central Areas Systems Study in 1970. In this study, the value of retained catenary light rail service, with collector on board the vehicle, was acknowledged, and the plan to convert the Riverside line to high platform service was scrapped for the planning period. The Staff Report describes the various elements of the Green Line Improvement Program which has been underway for the last few years. This work has included construction of new track, signals, power, communications, and new maintenance facilities for the LRV's. From sources other than the capital budget, the Authority has also rebuilt considerable amounts of track in conjunction with the MDPW's TOPICS and Urban Systems programs. Included in this category is a plan to install a preferential signal system along the Commonwealth line.

Projects now under consideration for inclusion in the Revised PMT are included in Section IV of the report. First in priority among these projects is the MBTA's proposal to rehabilitate 100 existing PCC vehicles to use as a back up fleet during the phasing in of the LRV fleet over the next three years, and thereafter for possible extensions and increased levels of service on the Green Line system. The Report summarizes the experience of the Authority with the delayed delivery schedule of the new LRV fleet, and notes the need to take immediate action to increase the level of reliability of the vehicles which will inevitably remain in service for an indefinite amount of time.

Other projects for possible inclusion in the PMT include the option of restoring streetcar service through Brighton Center, and possibly through to Watertown. The Staff Report shows that riders in the Newton Corner/Watertown area would receive severe degradation of service level if the light rail service were reinstated at the cost of removing some express bus service from the area. The Staff Report, therefore, focused operation and costing attention on a shorter extension to Oak Square in Brighton. For several thousand riders, this proposal would return the option of a 'one seat ride' to most major downtown destinations, although it would not improve door to door travel times. The operating costs, however, of converting from feeder bus service to through-routed light rail service , pose a major problem for the project. Operating costs for the comparable Brighton-Kenmore segment could rise by about $300,000 with the rail operation; and additional cost of about $500,000 would be attributable to operations between Kenmore and Park. This service would benefit far more than just Brighton users.

The Staff Report examines the potential alternative services to the suburban areas beyond Rte 128, and concludes that the abandonment of the 'B&A' commuter rail service would not result in operating cost savings if a bus service were provided with a comparable level of service by the MBTA. The Report notes that in this corridor, there is a clear need for both commuter rail and express bus services. There are some ways in which the capital budget of the Authority can be used to support the existing regional commuter services currently well operated by private carriers. The Framingham-Natick Transportation Study currently being undertaken by the CTPS has isolated several potential sites for improved multi-modal terminal points in the corridor. These sites are noted in the Staff Report, along with a list of possible improvements to the commuter rail service.

Part Two: The Core

The travel patterns between the Core and the rest of the region are presented in Section I of the Core Report, both in terms of radial travel to the core in the AM peak period, and in terms of trips with their origins in the core with destinations throughout the region. The flows to the CBD are particularly strong from the South Shore corridor, with about 33,000 trips, followed by the Northern corridor with about 28,000. This tends to support the 1966 PMT's decision to extend rapid transit to these two corridors as first steps in the regional program. However, it is significant that the strongest single contributor of trips to the CBD is none of the "corridors" as defined in these tables, but rather the inner communities of the rest of the core area. From these communities, 53,000 such trips are sent to the CBD, emphasizing once more the need to stabilize and improve transit services to the existing riders of the close-in neighborhoods. Section 1 also presents a summary of graphic descriptions of core-oriented travel by highway and transit.

Section II presents an analysis of the relative levels of accessibility in the CBD in two formats. In the first, land is examined to determine which zones are better served than other comparable zones. In the second kind of analysis, the separate transportation services themselves are examined in terms of their ability to perform downtown distribution services. Section II.A.1 of the Staff Report presents a brief summary of the relative accessibility levels of the various areas of the CBD. Then, Sections II.A.2-4 present summaries of the distribution characteristics of the rapid transit, commuter rail, and express bus services of the CBD. Data concerning the service levels and capacity characteristics is presented in Staff Report #2.

In Section III of the Core Report, demand for additional core distribution is analyzed. The Staff Report is concerned with a wide variety of possible improvements to the core transit system above and beyond the network already in place. Section II of the Report is concerned with the service characteristics of the existing (and committed) system. Section III is concerned with travel patterns not currently well-accommodated by the existing system. To support this kind of analysis it is not sufficient to examine an Origin-Destination trip table which describes the magnitude of all flows within the study area. Rather, what is needed is a methodology which defines the transportation flow that could be best handled by some kind of supplementary core distribution facilities.

Based on core distribution studies initiated during the BTPR, the PMT planning process has devoted considerable technical and policy attention to possible transit improvements in the center of the regional network. Demand for core distribution to supplement the committed core network has been modelled using detailed computerized transit simulation techniques. The Section presents a brief summary of the pattern of demand for core distribution services, on a community-by-community sub-area basis. The demand data here presented should not be confused with comprehensive origin-destination data. Rather, the trips shown in this section are only those trips which would be best served by supplementary facilities. The section contains eight capsule summaries of revealed demand for improved core distribution services, organized by geographic subarea. It examines distribution deficiencies of the existing transit network, and describes the characteristics of demand for additional services in terms of the service needs of the eight subareas.

Projects in advanced development, or under implementation, include the station modernization program, Huntington Avenue reconstruction, North Station pedestrian improvements, and the South Station Transportation Center. Those projects are discussed in Section IV.

Core projects in the planning phase are presented in Section V of the Staff Report. Green Line options are presented first, including a possible Huntington Avenue-Brookline Village connection, reconstruction of the right-of-way from Brigham Circle to Heath Street, North Station Green Line relocation, possible extension of the Green Line to Somerville, and a proposal to provide additional Green Line vehicle storage to serve the eastern portion of the Green Line service area.

Some longer term major downtown distribution improvements are presented in Section V of the report. The most heavily used stations on each of the three MBTA rapid transit routes and on

the light rail Central Subway are all contained in an area less than one quarter mile square in the heart of the Boston Central Business District. Within this area the Orange Line and the Central Subway (Green Line) each intersect both the Red Line and the Blue Line, and free transfers are permitted. The Orange Line and the Green Line connect at Haymarket Station, 1/4 mile north of their intersections with the Blue Line and again at North Station. However, there is no direct connection between the Blue Line and the Red Line. Passengers desiring to travel between stations on these two routes must make a double transfer via either the Orange Line or the Green Line.

The Blue-Green connection is one of two possible projects to improve interconnection at the Center of the network. The other project, the Blue-Red connection is discussed as a major alternative to the Blue-Green connection. At about $40 million, a Bowdoin-Charles tunnel could interconnect the Blue and Red Lines at the lowest possible cost. A possible Stuart-Huntington tunnel is discussed, with the alternative option of reconstructing the Central Subway to high-platform service as a long-term solution to the Back Bay distribution problem.

The Transit Circumferential Project is presented in Section V.C. of the Report. The Program for Mass Transportation will include initial recommendations as to the timing of implementation of the proposed improvements to circumferential transit travel in the core area. The Circumferential project was a major policy recommendation of the BTPR, and has been included in the latest TDP/TIP as a construction project for the 1980's. At the present time, the CTPS is about to undertake a major revision of the BTPR study with an emphasis on a program of phased incremental implementation of this major project. A major emphasis will be placed on the definition of early spin-off projects which can be advanced before resolution of legitimately core-wide issues. This section of the Staff Report reviews major planning information created to date. The major conclusions noted here, however, are subject to revision and re-examination in the comprehensive CTPS study now being undertaken.

The approximate cost estimate for the fixed facilities, (excluding right-of-way, property acquisition and land damage costs) for the different options of this project, as shown in Figure 12 of the Report, is summarized as follows:

I.	Grand Junction to Sullivan Square	$38,800,000
II.	Lechmere to Memorial Drive	23,300,000
III.	Memorial Drive to Boston University	34,600,000
IV.	Boston University Park Drive	51,500,000
V.	Park Drive to Huntington Ave., direct or via Longwood, including Ruggles	102,600,000 (127,600,000)
	TOTALS:	
	via Park Drive	$250,700,000
	via Longwood Avenue	275,700,000

Section VI of the Staff Report concerns possible use of commuter rail for core area stations. In the past, all of the existing commuter rail lines in the Boston area had stations much closer to the Boston terminals than the nearest stations now served. These inner suburban stations were gradually phased out beginning about 1920 and ending about 1960. A number of factors were responsible for closing of these stations. In most cases, patrons of these stations were also able to use combinations of streetcar and rapid transit service, or later buses and rapid transit. This alternate service, although offering slower running times,provided more frequent departures and lower fares. The inner suburban stations were generally served by short-turn trains rather than by through trains. As operation of short-turn trains became uneconomical, some attempts were made to serve the inner stations by having trains from more distant points stop at them. This resulted in lengthening the running times on the through trains, which discouraged ridership from further points to some extent. If the through trains were already operating at capacity, serving inner stops required adding extra cars and crewmen. This was costly, as the extra equipment and personnel had to be carried through to and from wherever the outer ends of the runs were, but might be needed for ten miles or less from Boston. Thus, the decision of rail management often was to give up entirely on inner suburban business.

The MBTA commuter rail office and EOTC have received a number of suggestions for additional reactivations of abandoned inner suburban rail stations, or creation of new stations. Some of these proposed stations, like those discussed above, would serve mostly traffic to downtown Boston. Possible locations for these stations are in Chelsea, Everett, and Somerville among others. Other suggested stations would serve as destinations for traffic from the outer suburbs as well as origins for intown traffic. Included in this category would be stations at Boston University, Northeastern University, and Tufts College. Preliminary analysis by EOTC staff of two potential inner suburban stations is described in this section.

Staff Report #5d

CAPITAL NEEDS AS DEVELOPED AT THE CORRIDOR LEVEL: THE WESTERN CORRIDOR

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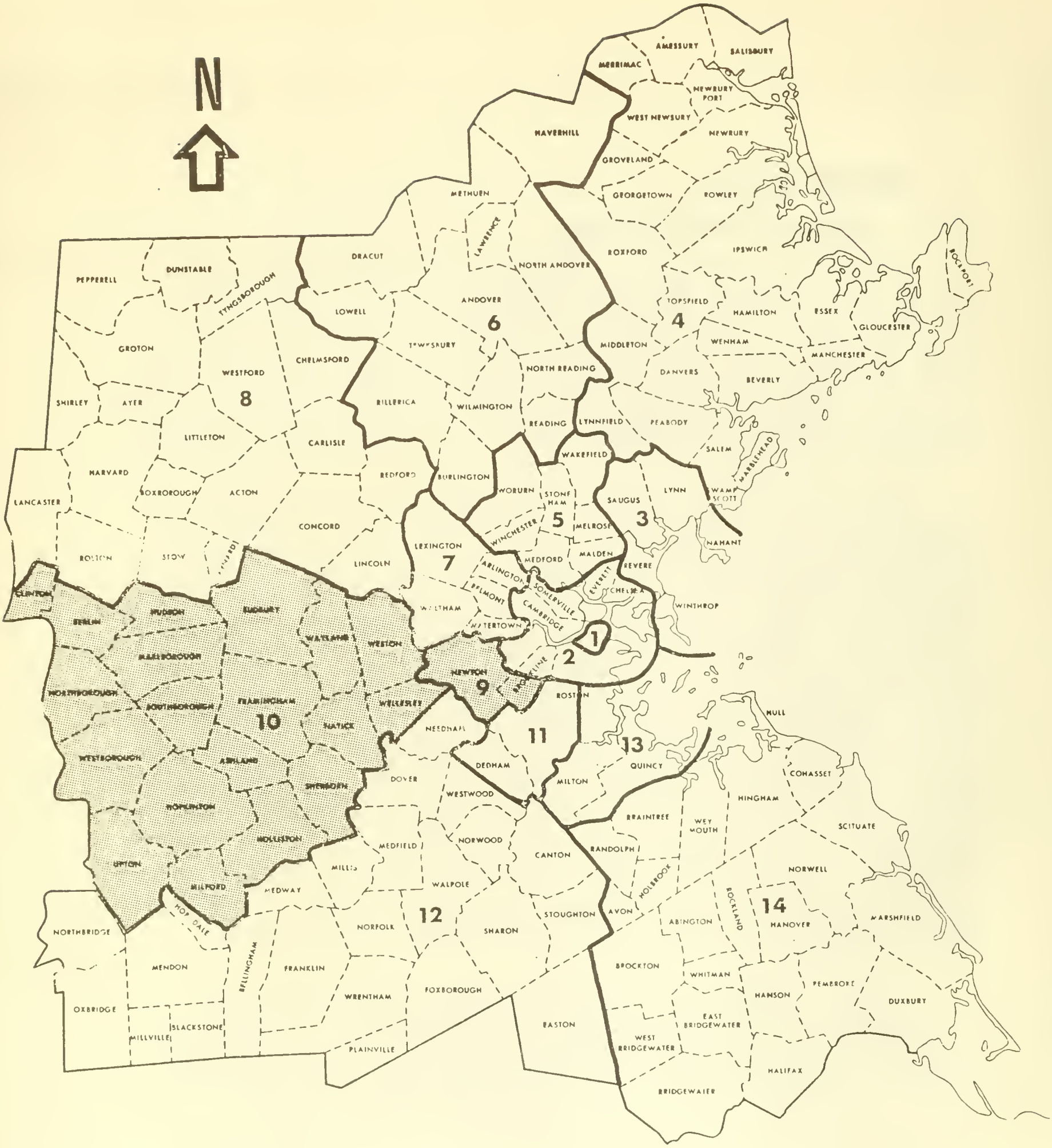
I. Regional Context

I.A. Regional Travel Patterns

The Western Corridor, extending from Newton-Brookline to the area between Clinton and Upton west of Framingham is moderately core-oriented compared with the other sectors of the region. Staff report #1 showed that 35.9% of all peak period trips originating in the corridor roughly within Route 128 were destined for the core communities and 11.6% of all external peak period trips originating in the corridor outside of Route 128 had the core as a destination (based on a 1980 trip table). These figures are presented in Table 1.

This corridor is served by the best grade-separated express highway in the region which directly serves downtown trips, the Massachusetts Turnpike. In addition, Route 9 through Brookline also serves the core from this corridor. However, between 40 and 44% of the core oriented peak period trips are made by transit. These transit trips are served chiefly by the Green Line which has branches into Brookline, Newton and Brighton, the longest of which goes to Riverside at Route 128. It is also served by one commuter rail line from Framingham, Natick, Wellesley and Newton into Boston. There are also numerous MBTA express bus services that use the Massachusetts Turnpike into the downtown. Finally, there are numerous local bus routes and a few private bus operations operating within the corridor providing a generally core oriented service. Travel times from the corridor, however, do not compare very well with those from other corridors, as seen in Figure 1, except for the express bus service which is not represented in that figure. The overall transit travel time is 30-40 minutes for the inner Western corridor.

Table 1 shows the regional travel patterns for the communities of Newton and beyond. More detail is needed concerning the specific travel patterns of the "streetcar suburbs" served directly by the Green Line. This information is provided below from actual 1963 survey data.



AGGREGATED ZONES USED IN PROGRAM FOR MASS TRANSPORTATION

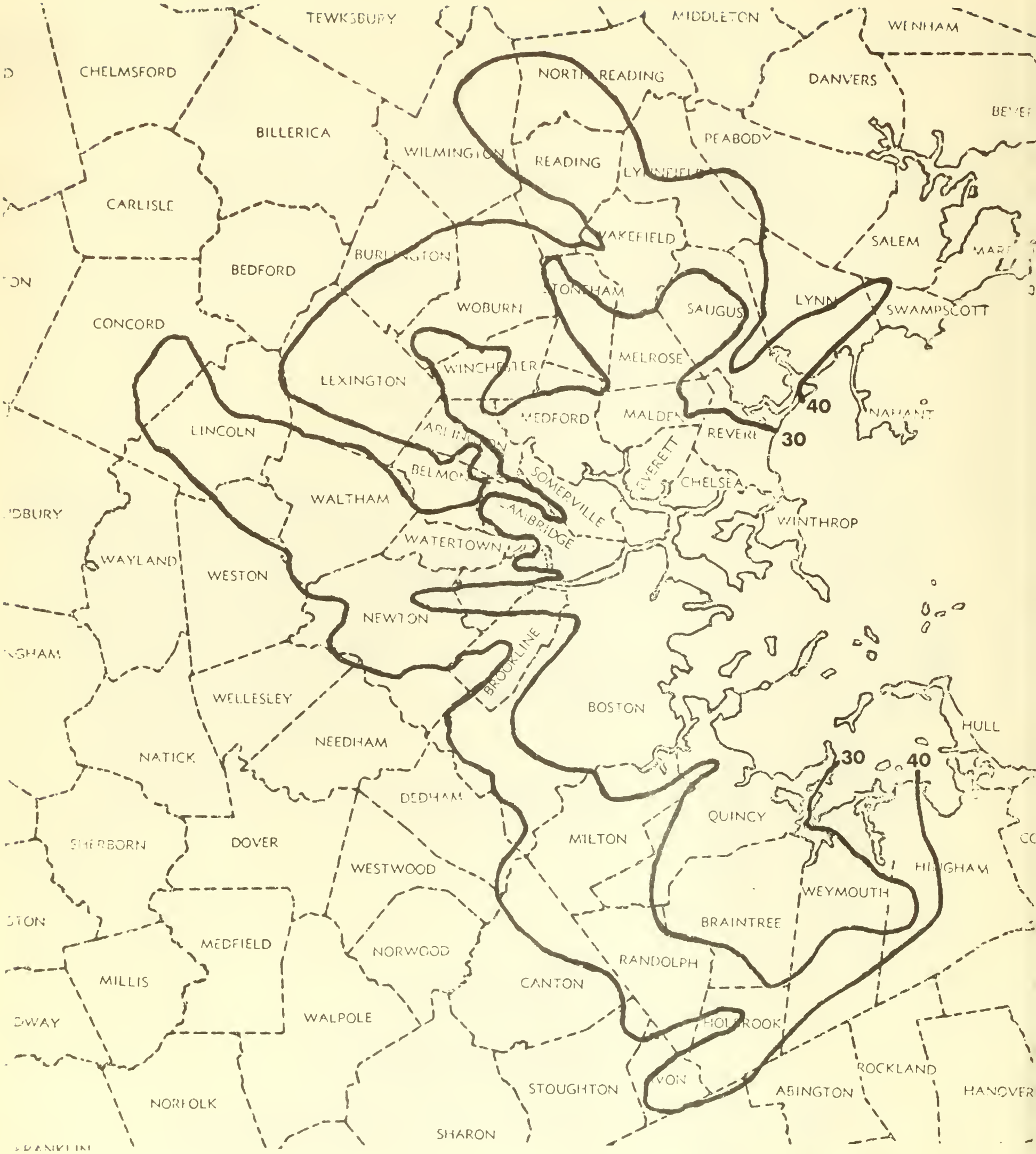
Showing Defintion of Western Corridor Used in Staff Report 5d.

TABLE 1

Western Corridor Trips

1980 Base Peak Period - All Modes All Purposes

Zone	Destinations	From Inner West (9)	%	% of External Trips	From Outer West (10)	%	% of External Trips
1.	Boston Proper	6,850	14.9	23.0	7,977	5.4	16.8
2.	Core w/o Boston Proper	9,689	21.0	32.5	9,083	6.2	19.2
3.	Inner NS	212	0.5	0.7	252	0.2	0.5
4.	Outer NS	182	0.4	0.6	423	0.3	0.9
5.	Inner North	375	0.8	1.3	706	0.5	1.5
6.	Outer North	291	0.6	1.0	1,247	0.9	2.6
7.	Inner NW	3,863	8.4	12.9	4,446	3.0	9.4
8.	Outer NW	516	1.1	1.7	7,471	5.1	15.8
9.	Inner West	16,190	35.1	Internal	4,099	2.8	8.7
10.	Outer West	3,034	6.6	10.2	99,479	67.7	Internal
11.	Inner SW	1,713	3.7	5.7	1,129	0.8	2.4
12.	Outer SW	1,928	4.2	6.5	9,111	6.2	19.2
13.	Inner SS	705	1.5	2.4	655	0.5	1.4
14.	Outer SS	438	1.0	1.5	786	0.5	1.7
	Totals	45,986			146,864		



1980 TRANSIT TRAVEL TIMES TO BOSTON CENTRAL BUSINESS DISTRICT

Figure 1

I. B. Travel Patterns of the Green Line Area

Analysis of Green Line ridership shows that the so-called "streetcar suburbs," those communities closest to the downtown including North Brookline, Allston, Brighton and Jamaica Plain, exhibit a high degree of core oriented transit trips to the downtown in the A.M. peak as shown in Table 2. The percentage of core oriented transit trips for these communities is between 30% and 45%. South Brookline, East Cambridge, Newton and Watertown are between 14% and 27% core oriented. The volume of ridership is highest from North Brookline with 4,033 transit peak core oriented trips, compared with 1,099 such trips for Watertown. See Table 3. Finally, Table 4 shows that transit trips ("modal split") from the Green Line communities to downtown is highest for Jamaica Plain, 75.6%, followed by Allston with 69.8%, compared with Newton at 44.3%. Overall, it is relatively clear from these tables that there is a high modal split in favor of transit usage among the streetcar suburbs for core oriented A.M. peak period trips.

TABLE 2

Extent of Downtown Orientation for Green Line Service Areas

Percentage of A.M. peak period transit trips going to downtown and Fenway destinations - 1963.

Origin	% to Downtown
North Brookline	45.1
Allston	36.4
Brighton	30.3
Jamaica Plain	29.4
South Brookline	26.5
East Cambridge	20.1
Newton	15.1
Watertown	14.1

TABLE 3

Magnitude of Transit Travel to Extended Downtown

Number of transit trips in A.M. peak period from Green Line Communities to Downtown and Fenway zones - 1963.

Ranked from Highest to Lowest

North Brookline	4,033
Brighton	2,723
Allston	2,475
Jamaica Plain	2,436
Newton	2,333
East Cambridge	1,802
South Brookline	1,168
Watertown	1,099

TABLE 4

Modal Split to Downtown

Transit trips as percentage of all peak period trips from Green Line communities to Downtown and Fenway destinations-1963.

Ranked from Highest to Lowest

Jamaica Plain	75.6
Allston	69.8
East Cambridge	64.1
Brighton	63.4
Everett	62.7
North Brookline	52.8
Watertown	52.1
South Brookline	45.3
Newton	44.3

DEMOGRAPHIC DESCRIPTION OF THE WESTERN CORRIDOR

TOWN	Population 1975	Population 1970	Population 1960	Percent change '60-'75	Med. income 1970	Population over 65 %	Area in Sq. Miles	Density person/ Sq. Mile	Percent Multi-Families	Med. No. persons per unit
Ashland	8906	8882	7779	14.5	11341	5.9	12.41	718	13.8	3.4
Brookline	53150	58886	54044	-1.7	13701	20.0	6.82	7793	NA	2.5
Framingham	65564	64048	44526	47.2	10843	8.8	23.92	2741	29.5	3.0
Holliston	12921	12069	6222	107.7	12380	4.8	8.9	684	11.5	3.7
Hopkinton	6405	5981	4932	29.9	10321	7.6	26.10	243	6.3	3.3
Marlboro	30249	27936	18819	60.7	11415	8.8	20.99	1141	23.0	2.9
Natick	31102	31057	28831	7.9	11613	8.1	14.88	2090	9.6	3.2
Newton	89183	91066	92382	-3.5	15381	12.1	18.33	4865	NA	3.3
Sherborn	NA	3309	1806	83.2	17833	5.9	16.89	196	0.7	3.8
Southboro	6326	5798	3996	58.3	12434	6.9	13.78	459	4.1	3.5
Sudbury	14951	13506	7446	100.8	16836	3.7	24.37	614	0.1	4.0
Wayland	13282	13461	10444	27.2	16025	6.0	15.78	842	1.4	3.7
Wellesley	26593	28051	26071	2.0	19413	10.8	10.05	2646	8.6	3.0
Weston	11478	10870	8261	38.9	23530	7.5	17.36	661	1.8	3.5
Met. Boston	NA	NA	NA	7.9	8742	11.3	NA	NA	37.7	2.6

Western Corridor

Automobile Availability

1970 Census

	None	%	1	%	2	%	3 or more	%
Ashland	252	10.3	1126	46.2	914	37.5	146	6.0
Brookline	6134	26.9	11718	51.4	4178	18.3	780	3.4
Framingham	1942	10.2	8805	46.4	7405	39.0	839	4.4
Holliston	142	4.5	1345	42.5	1511	47.7	168	5.3
Hopkinton*								
Marlborough	1102	13.2	4405	52.7	2573	30.8	277	3.3
Natick	774	8.7	4305	48.6	3189	36.0	591	6.7
Newton	2442	9.0	12721	47.2	9928	36.9	1868	6.9
Sherborn	14	1.6	214	24.6	543	62.4	99	11.4
Southborough*								
Sudbury	71	2.2	733	22.4	2144	65.5	326	10.0
Wayland	131	3.6	1055	29.2	2098	58.2	323	9.0
Wellesley	448	5.7	3055	39.0	3736	47.7	588	7.5
Weston	25	0.9	780	28.3	1585	57.5	365	13.2

* Not Available

II. Analysis of Existing Conditions - Western Corridor

This section of staff report 5d is concerned with major radial travel flows susceptible to improvement through capital investment. The section has three parts. First is presented an inventory of MBTA Express Bus, Private Carrier Bus, Commuter Rail, and MBTA Green Line services. Following this inventory is presented a summary of known user characteristics for these services. Finally, an analysis of many functions of the Green Line system is presented.

II.A. Bus Operations in the Western Corridor

II.A.1. MBTA Express Bus

300--Riverside Down Town Boston via Mass. Turnpike. Service every 4,5,15, and 30 minutes, depending on time of day, weekday rush hours only. Est. inbound ridership--1,200

301--Brighton Center Downtown Boston (Sumner and Chauncey Streets) via Oak Square, Tremont Street and Mass. Turnpike. Service every 7 and 15 minutes, depending on time of day, weekday rush hours only. Est. inbound ridership--850

302--Watertown Square Back Bay, Boston (Copley Square) via Newton Corner, Mass. Turnpike. Service every 10 and 15 minutes, depending on time of day, weekday rush hours only. Est. inbound ridership--430

303--Riverside Back Bay, Boston (Copley Square) via Mass. Turnpike. Service every 15 and 20 minutes, depending on time of day, weekday rush hours only. Est. inbound ridership--235

304--Watertown Square Downtown Boston (Sumner and Chauncey Streets) via Newton Corner, Mass. Turnpike. Service every 7,12, and 15 minutes, depending on time of day, weekdays and Saturdays only throughout day until 5:45 P.M. Saturdays and 5:15 P.M. weekdays. Est. inbound ridership--1,600

305--Central Square, Waltham Downtown Boston (Sumner and Chauncey Streets) via Moody Street, Waltham and Lexington Street, Commonwealth Avenue, Washington Street, Newton and Mass. Turnpike. Service every 15,20 and 60 minutes, depending on time of day, weekday rush hours only. Est. inbound ridership--550

II.A.2. Private Carrier Bus

a. Gray Line--Worcester to Boston - Park Square servicing Westboro, Fayville, and Framingham in rush hours between 6:30 A.M. and 8:45 A.M. Three leave Fayville between 7:13 and 7:28 A.M. Hourly off peak is provided. Operating hours are from 6:30 A.M. to 1:45 A.M.

Gray Lines also provide service from Worcester to Logan, servicing Framingham--Shopper's World and Marriott Motor Hotel, Newton. Two trips leave Shopper's World 6:05 and 7:05 A.M. in the peak with operating hours 6:05 A.M. to 9:05 P.M.

b. Wellesley Fells--Framingham to Boston via Route 9 - Park Square servicing Natick, Wellesley Hills, Newton Highlands, Chestnut Hill and Brookline Village.

Operating hours are 6:30 A.M. to 6:00 P.M. five trips leave from Framingham between 6:30 and 8:30 A.M. One and one-half hour headway are operated between 10:00 A.M. and 4:00 P.M.

c. Ritchie Bus Lines, Inc.--Operates express bus from Worcester to Boston via Route 20 Southboro and Marlboro.

II.A.3. Local Bus

57--Watertown - Kenmore via Washington Street, Brighton Avenue, and Commonwealth Avenue. Service every 4,5,8,9, 12 and 15 minutes depending on time of day and operates daily.

58--Boston College - Kenmore Square via Commonwealth Avenue. Service every 10 minutes and 14 minutes depending on time of day, weekday rush hours only.

60--Chestnut Hill - Kenmore via Cypress and High Streets. Service every 30 to 45 minutes, depending on time of day, and operates daily.

63--Cleveland Circle - Central Square, Cambridge via Market Street and Western Avenue. Service every 20,30, and 60 minutes, depending on time of day, and operates daily

64--Oak Square - Central Square, Cambridge via North Beacon Street. Service every 15,30, and 60 minutes, depending on time of day, and operates Monday through Saturday only.

65--Brighton Center - Kenmore Station via Washington Street, Brookline Village and Brookline Avenue. Service every 20 to 30 minutes, depending on time of day, and operates weekdays only.

520--Roberts (B&M Station) to Newton Corner via Central Square, Waltham. Half-hourly peak, hourly off-peak daily, hourly Saturday and Sunday.

521 Waverly - Newton Corner via Central Square, Waltham (passes B&M Station at Waltham) service approximately hourly Monday - Saturday.

522--Waltham Highlands - Newton Corner via Central Square, Waltham (passes B&M Station at Waltham) Hourly Monday - Saturday.

522A--Cedarwood - Newton Corner, via Central Square, Waltham (passes B&M Station at Waltham) Hourly Monday - Saturday.

527--Auburndale - Newton Corner via Bermis (passes B&A Station at Auburndale and B&M Station in Waltham) Hourly Monday - Saturday.

531--Framingham - Newton Corner via Natick and Wellesley (passes Riverside Line Woodland Station) Hourly Monday - Saturday.

532--Needham - Watertown via Newtonville (passes Newton Highlands on the Riverside Line and Newtonville on the B&A) Service every 45 minutes Monday - Saturday.

533--Oak Hill - Newton Corner via Newton Center (passes Newton Centre on the Riverside Line) Service every 70 minutes Monday - Saturday.

535--Auburndale - Boston College via Commonwealth Avenue (services Boston College Station on the Boston College Green Line) 6 trips a day on weekdays only, 3 in morning and 3 in evening.

II.B. Commuter Rail

The Western Corridor is presently served by one Penn Central (now called Conrail) commuter rail line which operates west out of Boston to Framingham, a distance of 21.5 miles on the so-called Boston and Albany line. There are 11 stations

on the line located in Framingham, Natick, Wellesley, Riverside, Auburndale and Newton. Weekday service consists of 5 round trips, 3 inbound in the morning with 2 inbound in the evening; and 2 outbound in the morning and 3 outbound in the evening. There is no weekend service. Approximately 630 one way daily riders are served.

II.C. Light Rail Service

Transit service is provided in the Western Corridor through the 3 Green Line light rail operations which originate in Riverside, Cleveland Circle, and Boston College and feed into the Central Subway from Kenmore Square through to North Station and Lechmere. Excluding the Arborway Line which serves the Southwest, the Western lines carry an average of 55,000 inbound riders per weekday. PCC streetcars are used exclusively in Green Line service in trains of 1 to 3 cars in length.

II.C.1. Riverside

The Riverside line which essentially serves Brookline and Newton is a converted commuter rail line. The MTA constructed the electrified light rail service in 1959.

The present route is completely grade-separated and terminates in Riverside. Most of the stations are former commuter rail stops. Riverside and Woodland stations were relocated from their original locations and Fenway Park station was added.

Riverside service is provided on 11 minute peak period headways with trains of 2 and 3 cars in length. In the off-peak period service is provided on 12 minute intervals the longest scheduled headways being 15 minutes. The line was used by between 8000 and 12000 inbound riders per day during the construction period. The heaviest peak hour is between 8:00 A.M. and 9:00 A.M. inbound. The trains on this line turn at the loop at North Station, and no longer operate through to Lechmere.

The average run time from the various Riverside line stations to Park Street are listed here.

Station	Run time to Park Street
Riverside	35 Minutes
Woodland	33 Minutes
Waban	31 Minutes
Eliot	29 Minutes
Newton Highlands	27 Minutes

Station	Run time to Park Street
Newton Center	25 Minutes
Chestnut Hill	22 Minutes
Reservoir	19 Minutes
Beaconsfield	18 Minutes
Brookline Hills	16 Minutes
Brookline Village	14 Minutes
Longwood	12 Minutes
Fenway Park	11 Minutes

There are some 3,500 parking spaces along the Riverside, not all of which are designed for commuter use.

II.C.2. Boston College

The Boston College line operates beyond the portal at Kenmore exclusively in a semi-private median all the way down Commonwealth Avenue to Boston College on the Newton-Brighton line. It essentially serves the Allston-Brighton section of Boston. There are no formal stations except at Boston College Station. Asphalt loading zones instead are used at all the other stops. The length of the surface portion of the line is about 4 miles.

Headway on the line are about 6 minutes in the peak and 9 to 10 minutes in the off-peak. Ridership on the surface one way inbound 24 hours is reported to be about 13,000. Train length varies from 1 to 3 car trains.

II.C.3. Beacon Street

The Cleveland Circle line operates beyond the portal at Kenmore exclusively in a semi-private median on Beacon Street in Brookline to Cleveland Circle in the Chestnut Hill section of Brighton. This line essentially serves Brookline. There are no surface stations except at Coolidge Corner although passenger shelters are located at almost every stop. The length of the surface portion of this line is about 2½ miles.

Headways on the line are about 6 minutes in the peak and 7 to 10 minutes in the off-peak. Ridership one way over a 24 hour period is just under 10,000 riders inbound on the surface portion of the line. Train length varies from one to three cars.

II. . Analysis of the Green Line System

Section II.C., above, has described the surface operation characteristics of the Green Line. However, the Green Line network is considerably more complex than a simple radical suburb to downtown service. Its problems and potentials can only be understood by observing its full network functions.

It is important to realize that much of the Green Line service area is a major regional destination area. The Fenway Hospitals area along the Huntington Line; the Fenway School district approached from the Riverside line; the Boston University area on the Commonwealth line; all of these areas are important destinations for regional trips needing core distribution.

Approximately fifty-eight thousand patrons are collected by the various Green Line segments during the day. Of these, 35,000 are carried into Boston Proper from Kenmore, 14,000 from Huntington Avenue Line, and 9,000 from Lechmere in East Cambridge. Fifteen thousand of the riders have one end of their trip in the Green Line service area and the other end outside Boston Proper. This means that 43,000 riders alight in Boston Proper daily from Green Line service areas. The Green Line's exceptional ability to distribute riders throughout this area is amply illustrated by the fact that only seven percent (or 3,000) of Green Line Boston Proper riders alight or board at stations not on the Green Line. The largest of these stations is South Station, which serves about four percent of the patrons who board the Green Line in its service area.

An examination of the role of the Green Line in distributing patrons to and from other corridors is particularly illuminating.

Specifically, about 16,000 riders in the Red Line Dorchester corridor transfer to and from the Green Line at Park Street daily. By far the majority of these patrons travel to or from Back Bay destinations. Some riders transferring from or to the Red Line were actually Orange Line riders making a double transfer--as many as 3,000 of them.

The Blue Line from East Boston provides 6,000 patrons each day with connections or distribution via the Green Line. Ten thousand transfer to and from the Red Line Cambridge subway at Park Street each day, and 3,000 to and from the Orange Line at Haymarket Square. This makes a total of 35,000 patrons making daily transfers to or from the Green Line and using other Massachusetts Bay Transportation Authority rapid transit services as part of the trip. Of these at least 20,000 are alighting at Green Line stations within Boston Proper, with the remaining 15,000 either coming from or going to Green Line stations outside Boston Proper. Many are actually going to the Back Bay or Fenway areas, which are growing most rapidly in institutional functions and which have effectively extended downtown geographically to the west. In Boston Proper alone, the Green Line can safely be said to accommodate 63,000 corridor riders--43,000 from its "own" corridors, and 20,000 from other rapid transit corridors.

In addition to the downtown distribution of its own corridor patrons, and 20,000 rapid transit patrons, the Green Line plays a most important role in intra-downtown trip making. On-going distribution studies have isolated about 24,000 of these trips, attributable to various phenomena. A large proportion of these trips can be directly attributed to certain access needs in the downtown network. Commuter rail riders, for example, arrive downtown in somewhat remote locations, from a pedestrian point-of-view. Research efforts of the Authority have shown that North Station train riders who finish their trip by transit, use the Green Line in two out of three instances for downtown distribution. Trips between the retail core and Back Bay are largely made through boardings at Green Line stations.

The high line volumes on the streetcar-subway are comprised of two-directional distribution. The boarding counts and levels of station activity in the Back Bay area might lead one to the conclusion that the desire lines of Green Line corridor patrons are strongly oriented towards the Back Bay. In fact, at least 60% of the alignments at Copley Square, for example, come from the east, with the Central Subway acting as a shuttle distribution line from other rapid transit lines. Likewise, of the 8,00 boardings at Kenmore Square, in the center of the institutional district adjacent to the west edge of Boston Proper, the majority of riders were going toward the transit connections at the center of the network, not toward the contiguous communities of the west. The opposite seems to be true of those alighting at Park and Government Center. These are overwhelmingly patrons from the west who finish on foot trips made deep into destinations of the Financial District. These destinations are approached from Park Street Station which is approximately a seven-minute walk.

II. D. Characteristics of Transit Users, By Mode

II. D. 1. Characteristics of Green Line Users

The inner Green Line systems services a residential area very much influenced by the streetcar network established at the turn of the century. This section reviews certain characteristics of the resident transit riders from this area. What emerges is a pattern of high competition by downtown oriented individuals for apartment space along the streetcar lines. This has an effect on larger family units who tend to move elsewhere rather than compete for apartment space with younger, core-oriented renters.

Transit services, at one time the staple of the majority, have become more and more relevant to the needs of particular groupings of people. The determinant factors include: stage in the life cycle, with particular respect to the child rearing process of families; density patterns at place of occupation (including students), and need for a second member of the household to join the labor force.

Table 5 presents in brief tabular form a summary of variables that highlight the unique character of each of the lines. The streetcar routes are presented individually. The Commonwealth-Beacon Line serves an older age group than the Huntington Line. Blue collar workers are more predominant on the Watertown Line. There are fewer office clerks riding the Huntington percentagewise than any other line.

Observation of the housing patterns of the Green Line area reveals how the presence of transit services affect the use of the housing stock. While transit may not influence the form taken by the majority of new single home developments, its effect on the existing housing near its services is market. Housing located near Green Line facilities has a significant concentration of groups other than families in the child rearing stage of their lives (25 to 40 years old). The family size of Beacon and Commonwealth patrons is significantly smaller than other lines in the system; in fact, the percentage of unrelated individuals in households is among the highest and is quite comparable with university areas of Cambridge, indicating the presence of both youthful and elderly persons.

The desires of families with children to seek housing patterns with more space and often better schools gives the Green Line service area as a whole an underrepresentation of employed persons ages 25 to 40. When the "suburban" Green Line service areas, such as Newton and South Brookline, are excluded, the streetcar-oriented communities of Allston, Brighton, North Brookline, Back Bay and Fenway would show even more marked differentiation by age. For the Green Line service area, those 16 through 25 comprise 23% of the trip making population for all modes, while those 26 through 35 comprise only 17% of the trip making population. The effect of age on trolley ridership is markedly increased by the differing tendencies of these groups, once located, to consume transit services: those 16-25 make up 31% of all trolley riders, with those 26-35 comprise only 12%.

Socioeconomic Characteristics of Green Line Riders, from 1963 EMRPP

	Individual Lines				
	Green Line	River-side	Hunting-ton	Water-town	Commonwealth Beacon
Without Autos	39%	22%	44%	38%	45%
Females	52%	47%	51%	52%	54%
Driver's License	54%	65%	45%*	48%	57%
		*13% are underage.			
Median Income	$9,000	$13,050	$7,290	$7,800	$9,600
Median Age	32	32	23	39	44
Persons in Households	3.41	3.92	3.19	3.75	2.79
Trips:					
Work	47%	50%	32%	51%	50%
School	21%	14%	36%	13%	16%
Other	32%	36%	32%	36%	34%
Professionals	15%	23%	9%	12%	18%
Office Clerks	24%	21%	16%	23%	28%
Blue Collar	14%	11%	9%	26%	8%
Sales & Service	6%	6%	7%	3%	6%

It also appears that streetcar tripmakers between the ages of 25 and 40 are significantly less affluent than both younger and older tripmakers. The date show that those residents at this stage in the life cycle are less likely to be so located by preference as their residential options are more constrained by income.

Housing arrangements catering to the needs of small families and unrelated individuals can effectively outbid working class family housing. There emerges on a line of high service levels, such as the Commonwealth Line, a pattern in which young and other unrelated households appear in disproportionate numbers among the ridership. Thus, while secretaries and office clerks (largely female) comprise only 14% of the region's total labor force, they appear as 28% of the Commonwealth ridership. Of course, these categories are not neat and mutually exclusive. Many families have additional wage earners in these occupations.

II.D.2. Characteristics of MBTA Express Bus Users

In 1971, the MBTA undertook an 100% sample survey of the express bus riders on the MBTA western corridor services. The major socio-economic data from that study are presented in this section of the Staff Report.

a. Occupation of MBTA Express Bus Users

	NA	Professional Managerial	Store/Office clerks	Traveling sales	Blue collar	Housewives & retired	Stu den
Riverside	1%	58%	23%	3%	6%	8%	1%
Brighton	2%	25%	48%	1%	11%	8%	5%
Watn-Dw	5%	33%	27%	1%	8%	16%	10%
Watn-Copley	4%	33%	29%	2%	6%	4%	22%
TOTAL	4%	36%	30%	2%	8%	11%	9%

b. Age of MBTA Express Bus Users

		AGE LEVELS			Senior Citizens	
	NA	10-29	30-49	50-69	70+	65+
Riverside	4%	24%	43%	25%	4%	7%
Brighton	8%	33%	27%	28%	4%	10%
Watn-DW	4%	36%	29%	26%	5%	9%
Watn-Copley	8%	52%	21%	18%	1%	5%
TOTAL	6%	35%	30%	25%	4%	9%

c. Sex of MBTA Express Bus Users

	NA	MALE	FEMALE
Riverside	1%	69%	30%
Brighton	1%	38%	61%
Watn-DW	2%	47%	51%
Watn-Copley	4%	44%	52%
TOTAL	2%	49%	49%

d. Household Size of MBTA Express Bus Users

		PERSONS			
	NA	1	2-3	4-5	6+
Riverside	3%	4%	45%	38%	10%
Brighton	3%	11%	50%	25%	11%
Watn-Dw	5%	9%	44%	29%	13%
Watn-Copley	6%	9%	46%	26%	13%
TOTAL	5%	8%	45%	30%	12%

e. Auto Availability, MBTA Express Bus Users

	Not Ascertainable	Captive Riders	Choice Riders
iverside	1%	14%	85%
righton Center	2%	53%	45%
atn-Dw	1%	46%	53%
atn-Copley	3%	52%	45%
OTAL	2%	42%	56%

f. Use of bus in one direction

	Watn-Dw	Brighton Ctr.	Riverside	Watn-Copley
o Reply	2%	3%	2%	3%
wo-way usage	68%	78%	70%	70%
ne-way usage	30%	70%	29%	27%

II. D.3. Characteristics of Framingham/Natick riders of Express Bus and Commuter Rail

The staff of CTPS conducted a pair of surveys on a weekday in the month of November, 1975. The express bus survey was conducted on Thursday, November 13 between the hours of 6:45 a.m. and 9:30 a.m. A total of 592 express bus survey questionnaires were distributed and 358 completed questionnaires were returned. Gray Line has informed CTPS that the express bus service from Shopper's World carried 756 passengers inbound that day. This means that 47.4% of the passengers completed the survey forms. This is a large enough sample to expand the survey data to reflect total daily inbound ridership.

The commuter rail survey was conducted on Tuesday, November 18 for the three scheduled inbound Penn Central commuter trains. 602 passengers boarded at the following stations: Framingham; Natick; Wellesley; Wellesley Hills; Wellesley Farms; Auburndale; West Newton; and Newtonville. Of the 602 surveys handed out, 552 were completed and returned for a 91.7% sample; this was considered likewise large enough to be representative of commuter rail ridership on this line.

a. Occupation. There appears to be a slight difference with respect to occupations between express bus users and commuter rail patrons, as indicated in Figure 9. A slightly higher percentage of executives and professionals use commuter rail (77.2%) compared to express bus (72.1%). Students from the group show a slightly higher usage of express bus (9.1%) compared to the commuter rail (2.2%), again due to the lower cost and more flexible and frequent service provided by the express bus.

b. Age. The Table below indicates the percentage of express bus and commuter rail users in each age group. From this table, one can see that the bulk of the express bus riders (49.6%) are between the ages of 26 to 40 years old whereas the largest percentage of commuter rail users are in the 41-65 year age group.

Therefore, it can be deduced that the average express bus rider is younger than the average commuter rail patron.

Age Group	Age Group of Commuters Shopper's World Express Bus	Commuter Rail Line
Under 16	0.3%	0.2%
16-25	24.5	10.0
26-40	49.6	38.1
41-65	24.5	48.4
over 65	1.1	3.3
Total	100.0	100.0

c. Sex. The percentage of females on the express bus was higher (46.4%) than on the commuter rail (20.2%). This may be attributed to the more flexible bus scheduling and the lower fares of the express bus. The majority of females using the express bus classified their occupation as sales/clerical; persons in this job category would tend to have lower incomes than the executive/professional classification, and would therefore be attracted to the lower fare.

d. Auto availability. From the surveys, it appears that the vast majority of express bus and commuter rail patrons had an automobile available to them to make the trip to their final destination. Approximately 78.6% of the express bus users had a car available while approximately 66.7% of the commuter rail patrons had a car available for the trip. This fact indicates that commuters are willing to use park-ride transit facilities rather than driving into the Boston core area.

e. Trip Purpose. The overwhelming majority of trips are work trips for both the express bus and the commuter rail. The commuter rail ridership is more worktrip-oriented (97.3%) than the express bus ridership (89.6%). There appears to be a greater percentage of school/college trip being made on express bus (8.9%) rather than commuter rail (7.2%). This may be explained in two ways. First, the express bus fare is less than the commuter rail fare. Express bus fare is $1.04 per ride if a twelve ride ticket is purchased; the twelve ride ticket from Framingham results in a $1.50 per ride fare and from Natick results in a $1.28 per ride fare. Second, express bus service is more frequent than commuter rail service. Between the hours of 7:00-9:00 a.m., ten express bus trips are scheduled, whereas only three commuter trains leave Framingham during the same time period. More importantly, express buses return to Framingham from Boston more frequently than commuter rail which better accommodates a students flexible schedule. From the survey, it appears that the express bus is used for shopping trips more than commuter rail; this also can be attributed to the inflexible commuter rail schedule.

III. Western Corridor Projects Undertaken Since 1966

III.A. Green Line

The 1966 Program for Mass Transportation recommended that the Authority leave the Riverside line as a low platform operation for an uncertain period of time and begin the process of service upgrading with new track and roadbed, new maintenance facilities and a partial fleet of light rail vehicles. The PMT noted that the future of the light rail services in the Western Corridor would be determined by a major study called The Central Area Systems Study. The 1966 PMT contemplated an eventual conversion of the Riverside Line to high platform service. Thus, only enough vehicles for service on Beacon, Commonwealth and Huntington Lines were included in the 1966 PMT.

III.A.1 The Central Area Systems Study

The Central Area Systems study was undertaken, and published in 1970. After an exhaustive engineering study of various long term, capital intensive solutions, the study concluded with a strong recommendation that the Authority concentrate its efforts on making the entire existing light rail network perform to its highest potential. The concept that a partial fleet should be purchased within the concept of a near term conversion to rapid transit was rejected in the Central Area Systems Study. That work went to considerable detail to point out that the collector-on-board catenary rail service offered by the Green Line was inherently desirable.

The Central Area Systems Study was significant in the development of the present capital development policies adopted by MBTA and EOTC. First, it was the first formal recommendation that the Authority concentrate on incremental improvement through near term investments. This was critical at a time when the Authority was delaying Green Line improvements because of uncertainty concerning the details of a long term solution. Secondly, the CASS Report was the first planning study to call for an investment strategy oriented toward improving service to existing riders while pursuing an aggressive expansion program. These planning concepts - of incrementary near term improvement in order to build ridership by improving transit quality to existing service areas, was adopted and developed further in the Boston Transportation Planning Review.

III.A.2 Development and Purchase of the LRV

By 1971, the Authority had rejected the high platform strategy, and received a capital grant to design the standard light rail vehicle. The objective of the project was to design a standard light rail vehicle that could be used by many different cities, based upon the belief that a standard design would increase the market for such a vehicle and lower its production cost.

The project accomplished this objective in a variety of ways, some of which were:

- Agencies considering phasing out of current light rail operations were encouraged to retain and improve them.

- Cities which were planning new transit systems were offered a "new" mode, light rail for consideration.

- Cities which had an immediate need for replacement of obsolete vehicles mutually agreed to combine their requirements in order to obtain a lower unit price.

- The specification was a performance type, thus encouraging additional suppliers to submit bids to prime manufacturers.

- Advanced technology subsystems were incorporated into the specification (i.e., chopper system, mono-motor truck, etc.) and arrangements were made for extensive equipment tests at UMTA's Transit Test Track near Pueblo, Colorado.

The success of the project also can be measured in monetary terms. Early in 1971, the San Francisco Municipal Railway requested bids for 78 new 76-foot, three-truck, articulated cars. Only two conforming manufacturers bid on the order, and the lowest conforming bid was $473,000 per unit. After consultation with UMTA, the bids were rejected as excessively high.

In November 1972 (a year after the original MUNI bid opening), a new standard Light Rail Vehicle specification, which blended equipment needs with practical cost considerations, was published and bids solicited. Two hundred thirty, 71-foot, six axle, articulated cars were required; 80 for San Francisco and 150 for MBTA. This time, five manufacturers submitted bids.

The lowest bid, including spare parts, and add-ons was $316,616 per unit for MUNI's 80 vehicles, and $293,422 per unit for the MBTA's 150 vehicles, a saving for MUNI of $136,384 per unit over the price of the 1971 vehicle.

The Standard Light Rail Vehicle specifications which grew out of this UMTA demonstration grant to the Authority have been published, and are available to PMT participants.

In 1974, the Authority reaffirmed its commitment to LRV's as the long term Green Line technology by ordering 25 additional LRV's with an UMTA capital grant of $9.5 million.

III.A. 3 Plant Improvements to the Green Line

The second aspect of the MBTA's program, in addition to a new fleet of vehicles, has been a program of Green Line plant improvements, with $38.1 million funded in 1972. The program has covered track, structures, power, signals, communication, and a new maintenance facility.

a. Track and Roadbed Improvements: Replacement of worn rail, ties and hardware using new welded rail. Surfacing and lining all track and reballasting as required. Drainage improvements at selected locations on Highland Branch and surface lines. Installation of emergency sirgle and double crossovers on the Highland Branch and in the Central Subway. Provisions for turnback facilities at Canal Street Station for new double-end cars.

b. Structure Improvements: Modifications to structures and track to provide clearance for new cars (mostly in the subway). Resurfacing platforms to accommodate track improvements and lengthen for longer trains on the Highland Branch. Provisions for additional fencing for Highland Branch. Additional heating and modernization of existing station facilities. Also included was the relocation and consolidation of platforms. Provisions for lighting of stops and crossings at selected locations.

c. Power System Improvements: Consists of new substations; new feeders; and upgrading of the trolley system to permit use of higher performance cars and increased service; and new overhead wire required for new Riverside Yard facilities.

d. Signal and Communication Improvements: Equipping of new cars, and the subway, with a train radio system. Also, provisions for base stations with antennas, for surface portion of the system, and a central radio control console. Modernization of signal system, and provisions for improved means of enforcing observance of signal and speed restrictions. Provisions for new signaling at Riverside Yard and at other locations where trackage will be changed. Provisions for automatic traffic control system and new interlocking at all junctions. Provisions for electric locking for all existing and new crossovers. Provisions for train identification system at selected Green Line points for purposes of line control, automatic routing at junctions, and actuation of automatic destination signs. Provisions for a public address system at seven Green Line station locations in the Central Subway and on the Lechmere Line. Provisions for automatic destination signs at all Central Subway station platforms serving multiple destinations. Provisions for equipment to allow preemption of selected street traffic signals by Green Line cars. Establishing and equipping a control center to monitor the state of the above listed systems, and control their operation.

e. Construction, Refurbishing and Purchase of Equipment for Green Line Maintenance and Repair Facilities: Construction and equipping of a new Riverside Carhouse, including a complete repair and inspection shop, maintenance equipment shelter, test house and pit, electrical power facilities, lockers, furniture, shop equipment, and landscaping. Refurbishing of the existing Reservoir Carhouse with new lighting, car washer, hoists, heating, track changes, and toilet facilities.

The Authority was awarded an additional $9.3 million to cover cost escalation on these projects on

III.A.4 Improvements from Operating Budget

Other improvement projects on the Green Line which have been funded out of the T operating budget have involved the rebuilding of track on the Boston College and Beacon Street Lines. The Beacon Street surface trackage had been rebuilt with the addition of new passenger waiting platforms and shelters. Work on the Boston College line so far is still in progress as track rebuilding along Commonwealth Avenue is still underway.

III.A.5 DPW Related Projects

Another project funded under the FHWA TOPICS program involved the installation of preferential traffic signals for street cars on the Boston College Line.

As part of a computerized signal system project for Commonwealth Avenue, MBTA Green Line streetcars operating on an at-grade reservation will receive preferential treatment at intersecting cross-streets through traffic signal preemption. The project is being undertaken jointly by the City of Boston, the Massachusetts DPW and the MBTA. The project should help to increase streetcar operating speeds and reduce bunching of trains. The project is moving toward implementation in early fiscal 1976.

III.B. Commuter Rail Changes Since 1966

At the time of the 1966 PMT, the Authority was not subsidizing commuter railroad service on the Boston and Albany Line. Service at that time was largely inter-city in nature, with two trains from Worcester, two from Albany in addition to two commuter runs from Framingham. Inter city service has been succesively cut back since that time, with only one inbound service operating at present.

The major change in terms of regional policy is the fact that the Authority now, since 1972, subsidizes service as part of its overall agreement with the Penn Central Conrail. Three trains are currently operated inbound in the AM peak period.

III.C. Express Bus Changes Since 1966

Express bus service to downtown via the Mass. Turnpike began in April 1965 when the Boston and Worcester Corporation originated express bus service from Worcester-Framingham over the newly opened Mass. Turnpike. Two year later in 1967 the MBTA started operating Mass. Pike express in from Watertown to downtown. A year later express service from Brighton Center-Oak Square commenced. In 1969 the MBTA started the Riverside express operation. The Watertown, Riverside, and Brighton service went to Summer and Chauncey Streets in downtown Boston. In 1971 the MBTA started routing some Riverside express buses to Prudential. Also that year MBTA express service from Waltham got started. Since 1971 various frequency changes have been made to the schedules but there have been no new express routes added since 1971.

FEATURES — *advancing Light Rail Transit*

HIGH FLOW VENTILATION OR HIGH CAPACITY AIR CONDITIONING SYSTEM

HIGH INTENSITY FLUORESCENT LIGHTING

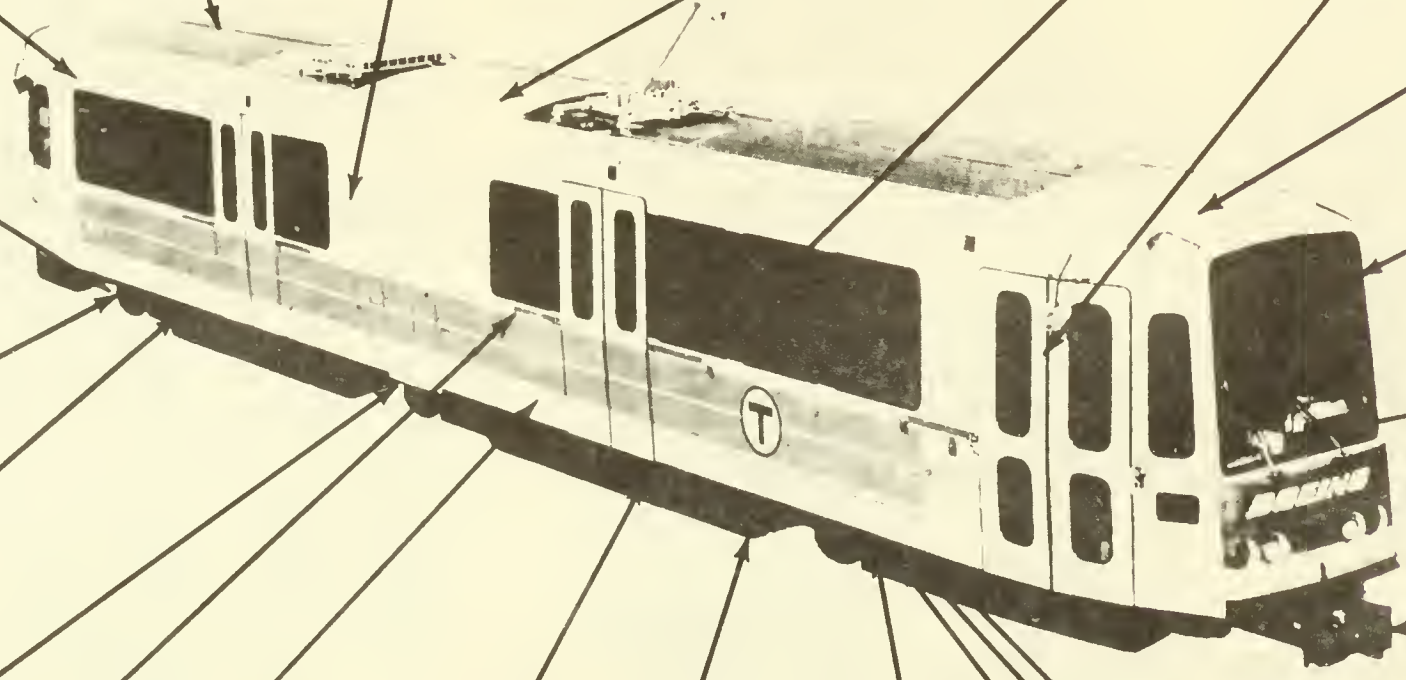
HUMAN ENGINEERED PASSENGER ORIENTED INTERIOR

SMOOTH-SIMPLE SEALED ARTICULATED SECTION

TINTED SAFETY GLASS WINDOWS

SLIDING PLUG DOORS WITH SENSITIVE EDGES

COR-TEN STEEL BODY CONSTRUCTION



CONSTANT FORCED AIR FLOW MOTOR VENTILATION

IMPACT RESISTANT WINDSHIELD

POWERED TRUCK

HUMAN ENGINEERED MOTORMAN'S CONSOLE

RESILIENT WHEELS

CRASH ATTENUATING COUPLER – DRAFT GEAR WITH ELECTRIC HEAD

UNPOWERED TRUCK

MONOMOTOR PROPULSION SYSTEM

CANTILEVERED-CUSHIONED MOLDED VANDAL-RESISTANT SEATS

SEALED INTEGRAL EQUIPMENT BAYS

CONVENTIONAL OR HIGH-LOW STEPS

LIGHTWEIGHT AIR SUSPENSION TRUCK WITH CHEVRON PRIMARY SPRINGS

DYNAMIC, PNEUMO-HYDRAULIC AND MAGNETIC TRACK BRAKES

POWERED TRUCK

SOLID STATE DC CHOPPER PROPULSION CONTROL

IV. Projects Under PMT Analysis

IV.A. Green Line Projects

IV.A.1. Vehicles

As stated in Section IIIA of this Staff Report, the Authority has purchased 175 Light Rail Vehicles from the Boeing Vertol company in Philadelphia. In January of this year, the Metropolitan Planning Organization inserted into the Transportation Improvement Program a program to rehabilitate 100 of the existing P.C.C. cars for continued operation on the Green line system. The MPO approved this program at the request of the Authority. The reasons for this additional vehicle investment are summarized in this section. The program is currently estimated at $10,000,000.

a. Timing of the LRV's. The original vehicle programming assumptions were based on theplanned arrival of the new LRV fleet sometime in 1975. At that point, PCC cars would gradually have been taken out of service and replaced by the newer vehicles. Due to several factors, the revised schedule for LRV arrivals reaches from now till sometime in 1978. This slippage in delivery schedule has had a drastic effect on the continued need for a partial fleet of PCC cars to operate at least for the next few years. It was the slippage of the LRV that brought the issue of additional back-up capability to a head, and focussed policy attention on the issues described in the following paragraphs.

b. Status of existing fleet. As noted above, the existing fleet was scheduled to be phased out of service at the present time. Of the 289 cars owned by the Authority, 185 are presently in operating condition. A series of heavy storms in December of 1975 showed the vulnerability of the remaining fleet to adverse weather conditions. The Authority has determined that an extensive rehabilitation program is needed immediately in order to continue the guaranteed availability of PCC cars through the period of mixed operations while the LRV's are being phased in.

c. Reliability of new Equipment. The Authority has experienced that newer equipment, with more sophisticated technology, tends to have unpredictable maintenance requirements as (a) the equipment is broken in and (b) as the staff becomes familiar with the changing needs of the technology. This situation is likely to be particularly acute in the case of the LRV's. Originally, San Francisco was expected to receive the first production units. With the continued slippage in the contract, it has been agreed that Boston will receive the

first set of vehicles. This can only increase the need to have considerable back-up capability during the first five years of operation. In short, the combination of new technology-such as chopper controls and articulated bodies-and initial production units demands a policy response to provide for back-up capability during the period of unpredictable maintenance conditions.

d. Additional services. Initial PMT scheduling calculations show that about 180 LRV's will be needed to provide an average five minute headway service on the existing lines including Mattapan. This figure includes a conservative 15% spares contingency which is considerably better than present operating condition. In short, it is clear that some additional vehicles will be needed to operate the proposed service, with the exact number to be determined by the actual experience. In addition to this need, the PMT is actively exploring possible additional service to Brighton, to Somerville and to the South End. While those needs are being developed, it is clear that there may be considerable need for an expanded fleet even after the break-in period for the new equipment.

A major factor in the decision to overhaul 100 existing vehicles is the rapid cost escalution of the LRV's. The present estimate of costs for additional cars range over $600,000 per vehicle.

IV.A.2. Maintenance Facilities

Staff Report #3 proposes the construction of a new facility to perform running repairs, light inspections and washing of LRV's and rebuilt PCC streetcars at the location of the present Reservoir Carhouse and yard. The new Riverside Carhouse would perform all major inspections and repairs. Because of the expanded maintenance capacity of the combination of Riverside and Reservoir, it is likely that the Arborway cars can be serviced at Reservoir and that the Arborway carhouse can be closed. Overnight storage of cars would continue at Riverside, Reservoir and Arborway but probably not at Lake St. on Commonwealth Ave.

The present carhouse is in deteriorated condition and should be replaced by modern facilities. Its location is ideal with respect to the Riverside, Commonwealth and Beacon lines so that minor repairs and certain inspections can be handled without recourse to the more remote Riverside facility. Staff Report #3 notes that alternatives to the project are being examined.

In addition, the Watertown car barn is slated for rennovation as the trackless trolley maintenance facility.

IV.A.3. Right of Way

The Authority proposes to continue the Green line project with the reconstruction of the track in the Central Subway. New roadbed is necessary to avoid undue wear on the new equipment, and improve the quality of service to Green line riders. A 4 million dollar program has been included for FY 76, with a total of $16 million for the full project.

IV.A.4. Further Parking Improvements

Section IIC of Staff Report showed a 1972 inventory of parking spaces along the Riverside line. Since that time the Authority has invested in capital improvements at most Riverside line stations. However, since 1972 the available parking supply has gone down considerably at Riverside station itself. The Revised PMT should include capital funding to increase the parking supply in the Riverside area. Some consideration should be given to adding additional parking for express bus users at a site close to the Turnpike entrance. However, there are major disadvantages to any two-site strategy when compared with the option of serving all modes from common parking and terminal area.

The need to increase parking supply for these services is critical. The Authority will be examing alternative additional parking options with the CTPS and the affected communities.

A second area for increased commuter parking has been isolated at Newton Corner. The City of Newton has expressed interest in redesigning the express bus access system at the Intersection of the Mass Turnpike and Center, Galen, Washington and other Newton local streets. The goal of the project would be to establish a parking facility for express bus riders, and to possibly provide for direct turnpike access for the buses from such a facility, with minimized interference with local traffic. The project will receive initial evaluation in the PMT, and be examined further by the Central Transportation Planning Staff.

IV. A. 5. Possible New Green Line Service

Resumption of Light Rail Service on the Watertown line

Streetcar service on the M.B.T.A.'s Watertown line was replaced by buses in 1969. Certain streetcar repair functions were subsequently transferred to the Watertown carhouse from Everett Shops, and the tracks and power distribution system on the entire line were left in place to provide access to the carhouse. Streetcar service on the Watertown line operated through the Boylston St. and Tremont St. subways to Park St. station, whereas the substitute bus service terminates at Kenmore Station, necessitating a transfer for passengers going further intown. Largely for this reason there has been community support, particularly in Brighton, for restoration of streetcar service on the line. One of the deciding factors in the initial conversion to buses was a growing shortage of P.C.C. streetcars due to their advancing age. However with delivery of the new Light Rail Vehicles (L.R.V.'s) equipment shortage will no longer be a barrier to restoration of Watertown service.

Tracks of the Watertown car line are located in streets, unseparated from general traffic, between Watertown Square and Packard's Corner in Brighton, a distance of 3.9 miles. At Packard's Corner the Watertown line joins the Commonwealth Avenue line, which is located on a center-of-street reservation, and Watertown cars ran over this line to the subway. Originally there was a reservation for the Watertown line between Union Square and Packard's Corner a distance of 0.9 miles, but this was removed during a street widening project around 1950. At Newton Corner the eastbound and westbound Watertown tracks both cross the Massachusetts Turnpike extension on a highway bridge. For all traffic other than streetcars this is a one-way bridge. Traffic in the opposite direction including the replacement buses uses a bridge located about one quarter mile further west. Restoration of streetcar service would require closing one lane on the streetcar bridge to general traffic. The scheduled running time for streetcar from Watertown to Park St. during peak periods would now be approximately 39 minutes, assuming average speeds for buses and streetcars were the same west of Packard's Corner. (Due to the inability of streetcar to go around other vehicles on their tracks actual average run times for streetcars would probably be greater than those for buses.) Between Packard's Corner and Kenmore bus running time is 1 minute less than streetcar time, despite the fact that the bus runs in the street and the streetcar is on a reservation, because the bus does not pick up local passengers. Approximately 1 minute is required to walk from the Kenmore busway to the subway platform, and there is an average perceived waiting time of 4 minutes for a car at Kenmore. Excluding initial waiting time, perceived travel time from Watertown to Park St. via bus to Kenmore

is 43 minutes, or 4 minutes longer than streetcar time. In this analysis all differences in travel times are assumed to take place between Packard's Corner and Kenmore, so the 4 minute differential applies equally at all points between Watertown and Packard's Corner.

In addition to the Watertown-Kenmore bus there are three M.B.T.A. express bus routes serving points on the Watertown streetcar line. Route 304, Watertown to Downtown Boston, has a peak period schedule running time of 19 minutes from Watertown Square to Summer and Chauncy Sts. The walk time from Summer and Chauncy to Park St. is about 4 minutes. Hence from Watertown to Park St. route 304 requires 20 minutes less than the Watertown-Kenmore bus with transfer and 16 minutes less than light rail. From Newton Corner to Summer and Chauncy Route 304 takes 16 minutes, or 20 minutes to Park St. including walk time; compared to 40 minutes for the bus via Kenmore and 36 minutes for light rail. Route 302, Watertown to Back Bay has a scheduled time of 18 minutes from Watertown to Copley Station compared to 39 minutes for the Kenmore Bus and 35 minutes for light rail. Route 301, Brighton Center to Downtown Boston has a scheduled time of 24 minutes from Brighton Center to Summer and Chauncy Sts. compared to 30 minutes to Park St. for the bus via Kenmore and 26 minutes to Park St. via light rail. Inbound buses on route 304 operate west from Brighton Center to Newton Corner to reach the Turnpike. As a result the running time advantage of Route 304 over the Kenmore bus and light rail increases for points between Brighton Center and Newton Corner. Under the current fare structure the express buses to downtown have the same fare as the combination of bus to Kenmore and streetcar to Park St., but express bus passengers who transfer to the subway downtown to reach final destinations must pay an additional fare. Service on route 304 operates from 6:45 A.M. to 6:15 P.M. Routes 301 and 302 have no mid-day service.

The running time comparison above indicate that for points on the Watertown carline west of Brighton Center the minimum running times to downtown Boston are provided by express buses run on the Mass. Turnpike. Therefore the greatest travel time improvements to be made by re-institution of light rail service would be at points east of Brighton Center. This is the area in which public support for light rail service has been greatest. At present City of Newton officials are taking no stand for or against the service, pending more complete analysis. However concerns have been expressed about additional traffic congestion problems at Newton Corner resulting from operation of light rail vehicles, and about possible impacts of light rail service on the M.B.T.A. deficit.

A preliminary analysis of operating costs for light rail service on the Watertown line has been conducted by E.O.T.C. staff. In this analysis it was assumed that light rail vehicles would operate between Oak Square and Park Street. Buses would operate from Watertown to Oak Square, where an off-street transfer station would be provided. The light rail service would operate with peak hour headways of 6 minutes compared to existing bus headways of 4 minutes in the peak hour. Otherwise schedules would remain approximately the same as at present in order to avoid waiting time increases. West of Oak Square bus frequency would be made the same as light rail frequency. The annual operating cost of this light rail and feeder bus alternative was estimated to be $960,000 per year greater than the cost of the present bus service from Watertown to Kenmore based on 1974 M.B.T.A. unit costs.

In this calculation it was assumed that light rail maintenance functions now performed at Watertown will be transferred to Riverside or Reservoir and the cost of track maintenance west of Packard's Corner is allocated to the Oak Square service. If the Watertown maintenance function is to be retained some track maintenance costs would be incurred anyway, but probably less than the amount needed for revenue service. If no track maintenance cost is charged to the Oak Square service, the cost increase above declines by $120,000 to $840,000. Of the estimated annual cost increase $517,000 consists of costs of operating cars between Kenmore and Park St. Only vehicle movement costs were included for this segment, because it was felt that station operating and maintenance costs and track maintenance costs would not be significantly affected. In the subway cars from Oak Square would serve some of the local travel between stations west of Park St. now served by the Beacon St., Commonwealth Avenue, and Riverside lines. This would reduce crowding on cars on these lines and would decrease average waiting times. Therefore costs of this portion of the service do not have to be justified entirely by benefits to Brighton riders. Similarly Oak Square cars would provide some benefits to riders now boarding Commonwealth Avenue Cars between Packard's Corner and Kenmore.

Approximately 4900 inbound riders per day are on board the Watertown-Kenmore buses when they reach Packard's Corner. Very few riders use the buses for trips entirely west of Packard's Corner, and these riders would not receive any of the benefits of restored light rail service. Of the 4900 daily riders, roughly two thirds board at stops from Oak Square east. Riders now boarding west of Oak Square would be forced to transfer at Oak Square under the configuration examined by E.O.T.C. For those traveling to points in the subway the transfer at Oak Square would replace the transfer at Kenmore. Because the headways of Oak Square cars would be lon-

ger than the combined headway of cars now serving Kenmore perceived travel times for riders going from points west of Oak Square to points east of Kenmore would increase by an average of 5.5 minutes excluding changes in initial wait time. Some of these riders would switch to turnpike express buses to reduce their travel times.

Persons riding Oak Square cars from points east of Oak Square to points east of Kenmore would save approximately 4 minutes per trip excluding initial wait time compared to the time via bus to Kenmore and a transfer. All peak-hour riders would experience perceived initial waiting time increases of 2.5 minutes, due to the lengthening of headways from 4 to 6 minutes. (This change is required in part by scheduling considerations in the subway).

The net user time savings of this configuation would amount to 8500 hours per year with a value of $25,500 using $3.00 per hour as the value of travel time. This is much smaller than the estimated increase in operating costs for light rail service between Oak Square and Kenmore alone. However the travel time savings may have been somewhat underestimated. Due to the crowded condition of Beacon St., Commonwealth Ave., and Riverside cars, riders now transferring from Watertown buses at Kenmore may not always be able to board the first car arriving at Kenmore. This would make the 'base case' travel times used above too low and would therefore understate savings of through car service. The computed travel time savings do not include benefits to local riders in the subway or between Packard's Corner and Kenmore. If, however additional capacity for local travel on these segments were found to be justified it could be provided by shuttle service beginning at Packard's Corner or Blandford St. rather than at Oak Square.

E.O.T.C. did not analyze operating costs for light rail service to points on the Watertown line east of Oak Square. Due to the relative cost characteristics of bus and light rail, the increase in light rail cost over bus cost would be greater than the amount computed above for any terminal west of Oak Square and smaller for any terminal east of Oak Square. Through light rail service to Watertown with the same schedules used in the Oak Square analysis would result in user benefits of $510,000 per year compared to existing service because none of the users would have to transfer. However, operating costs for the portion of the light rail service between Watertown and Kenmore would be $648,000 per year greater than the cost of the Watertown Kenmore Bus, excluding any incremental track maintenance cost. In addition increased costs of $517,000 per year would still be incurred east of Kenmore.

As yet no final decision has been made on the future of light rail service on the Watertown line. Before this is done more

precise data on ridership characteristics, transfer times, and probable operating policy must be obtained. If the unit operating costs of the new Light Rail Vehicles turn out to be much lower than expected this could have a strong influence on the decision to restore light rail service on the Watertown line.

IV. B. Potential Bus Replacement Service for Boston and Albany Commuter Rail

Rail commuterservice on the former Boston and Albany line currently consists of six weekday round trips between Boston and Framingham. However, of these trips half are really deadheads operated only because of a lack of layover facilities in Framingham. Although the deadhead trains are shown in public timetables, they seldom carry any passengers.

The plan for substitution of express buses for commuter rail service prepared for the MBTA in 1969 by the consulting firm of Simpson & Curtin did not include replacement for Framingham trains because at that time the service was not subsidized. However the service was subsequently placed under a subsidy contract, and therefore EOTC has prepared a bus substitution plan for this corridor as well as for the others. In designing the bus network the following criteria were used initially:

a) No-transfer service would be provided from each B&A suburban station to both Back Bay and South Station.

b) At each station one bus departure would be provided for each rail departure eliminated, with additional departures if required for capacity.

c) From each suburban station buses to Boston would be routed so as to minimize travel times.

The ramp layout on the Mass. Turnpike Extension at Copley Square does not allow eastbound traffic to enter or westbound traffic to leave Turnpike there. Consequently without construction of additional ramps it would be impossible for one bus to serve both Back Bay and South Station without traveling over local streets between them. Traffic congestion on the local streets in the peak periods would make the run time to South Station with a Back Bay stop excessively long. Therefore the EOTC analysis assumed that separate buses to Back Bay and South Station from each origin would be provided. No attempt was made to serve the Riverside railroad station because demand there is now practically non-existent. The number of B&A riders now traveling between station pairs outside Boston is also very small, so no attempt was made to serve this demand either.

The initial bus network developed by EOTC would have had routes to Back Bay and to South Station originating at six suburban B&A stations as follows:

A) Framingham Station via Rtes. 126 and 30 and the Mass Turnpike.

B) Natick Station via Rtes. 27, and 9, Speen St. and the Mass. Turnpike. (If operated by the MBTA routes A and B would not stop at Shopper's World in order to avoid competing with private carriers)

C) Wellesley Station via Rte. 16, Wellesley Hills Sta., Rte. 128 and the Mass. Turnpike.

D) Wellesley Farms Station via Glen Rd., Rte. 16, Rte. 128 and the Mass. Turnpike.

E) Auburndale Station via Auburn St., Commonwealth Ave., Washington St., West Newton Sta. and the Mass. Turnpike.

F) Newtonville Station via Washington St., Newton Corner, and the Mass. Turnpike.

The estimated annual operating cost for this service if run by the MBTA, assuming no productive use of personel could be made in off peak hours, is $1,327,000 per year based on 1974 MBTA unit operating costs. The annual cost of existing B&A service based on 1974 Penn Central allocation formulas is $1,098,000. However of this approximately $280,000 represents fixed system costs that would be re-allocated to other former Penn Central lines if the B&A service alone were discontinued. Therefore the avoidable cost of B&A service is $818,000 per year, or $509,000 per year less than the cost of the first EOTC bus alternative.

In the initial network, bus running times to Boston would have been less than the best potential rail times from several stations due to the express character of the bus operations. The largest saving was at Framingham where bus time to South Station would be 10 minutes less than the best rail time for a local stop service. (Current scheduled running times for B&A trains are longer than historical times, but this is a result of past Penn Central operating policy rather than track conditions. Historical times can probably be restored if an agreement can be reached with ConRail management.) The net travel time savings of the initial EOTC bus network compared to a speeded up rail service would amount to 7,050 hours per year, or a dollar value of $21,150 assuming $3.00 per hour as the value of travel time. This saving is much smaller than the predicted increase in operating cost.

A modified bus network developed by EOTC would route buses from Framingham to Natick via Rte. 135 and then over route B described above in place of separate routes A and B from Framingham and Natick. Route F from Newtonville would be eliminated. Passengers going from Newtonville to South Station would take existing MBTA route 531 through to Boston. Passengers going from Newtonville to Back Bay would take route 531 to Newton Corner and change there to MBTA route 302. The possibility of eliminating trips from Auburndale to South Station and serving demand at Auburndale and West Newton with MBTA route 305 (Waltham to Boston) was examined, but preliminary analysis indicated that this would lead to overcrowding on Route 305.

The estimated annual operating cost of the modified bus network is $933,000, or $115,000 per year more than the avoidable cost of existing rail service. There would be a net increase of 7450 user hours per year for the modified bus network compared to speeded up commuter rail, or a dollar value of $22,350.

The bus service described above could be operated at less cost by private carriers than by the MBTA. However insufficient information on the cost structure of private carriers in the area is available at this time to predict whether or not the service could be operated at a profit. Subsidization of private carriers by the MBTA would be less expensive than direct operation but would probably be subject to clarification in terms of labor agreements.

The cost of MBTA operation of B&A replacement service would be reduced if the operators required could be used for other off-peak service without merely idling other drivers. In the EOTC computations it was assumed that buses would be stored in Boston and deadheaded to the outer stations before the morning peak. Some cost reduction could be achieved by use of suburban storage sites for buses. Likewise commuter rail cost could be reduced by provision of overnight storage at Framingham.

IV.C. Potential Improvements to Commuter Rail Service on the Boston and Albany

On April 1, 1976 operation of all Boston area Penn Central commuter rail service was taken over from Penn Central by the new Consolidated Rail Corporation, (ConRail). Service will continue unchanged for a period of six months. By the end of that time a new subsidy agreement satisfactory to ConRail and the MBTA must be reached or else by law the service can be discontinued. At present it is not possible to predict

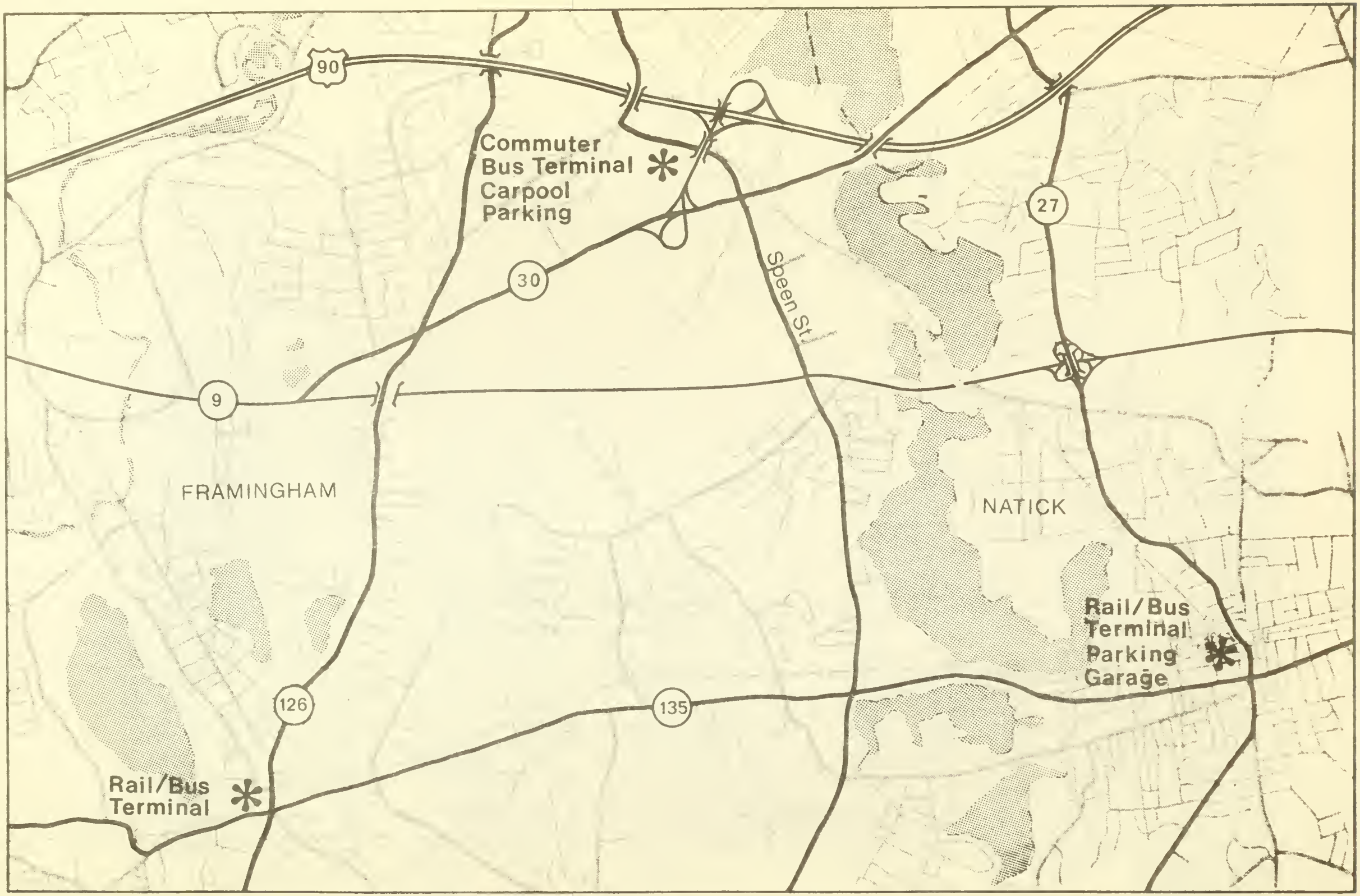
the form that a new subsidy agreement might take, or the receptiveness of ConRail management to upgrading of passenger service. However, barring institutional obstacles, a number of service improvements are possible.

- The scheduled running times for most B&A commuter trains are longer than necessary with existing track conditions. Speeding up of schedules would apparently require little more than issuance of new instructions to train crews.

- The train crews working on the B&A are underutilized because of the limited amount of service provided. Some off-peak service could be added with little or no extra cost for crews. (There would, however, be added expenses for fuel and maintenance of equipment.)

- Some communities west of Framingham (notably Westboro) have express interest in restoration of rail commuter service. At present all B&A trains are stored overnight in Boston and must be deadheaded to Framingham before the morning peak and back to Boston after the evening peak. If layover facilities could be provided in a community west of Framingham daily train miles for the existing service could be reduced. The savings would partially offset the cost of extra cars and train personnel needed to serve new riders. However the formula now used on former Penn Central lines for allocating costs to communities inside and outside the MBTA district would result in outside communities paying substantially more than the actual cost increase for extension of service beyond Framingham. Furthermore, at the present time the full cost of contract service must be paid by communities having stations, although the stations may be used by residents of other communities. Both of these factors discourage expansion of service but could be remedied by new agreements with the railroad, and by new legislation.

- At present the last evening train for Framingham leaves Boston at 5:45 p.m. In a survey of B&A riders taken by CTPS staff in November 1975 the most common suggestion for service improvement was that additional trains be run during the evening peak. A train leaving Boston later than 5:45 would not only serve those whose schedules always prevent them from taking earlier trains, but would also encourage additional use of earlier trains by providing "insurance" for those who may be afraid of occasionally missing the 5:45 train.



Proposed Regional Transportation Facilities –
Framingham/Natick Transportation Study April 1976

- Neither the Natick Station nor the Framingham Station has parking facilities set aside for commuter rail users. Park riders at the two stations must either use on street spaces or private lots. The Station Development Study to be conducted as part of the MBTA Commuter Rail Improvement Program will examine the feasibility of new or expanded parking facilities on all former Penn Central commuter lines in the Boston Area, including the Boston and Albany. A redevelopment plan for downtown Natick includes a new municipal parking lot adjacent to the B&A line. Development of the site for both local and commuter parking needs should be investigated jointly by the MBTA and the town.

The town of Framingham is working on plans for expansion and improvement of existing off-street parking near the railroad station. The town planning department has recommended close cooperation between the town and the MBTA with respect to Commuter rail improvements.

IV D. Multi-modal Strategies

The two sections above serve to point out the viability of both express bus and commuter rail options in this corridor. In other Staff Reports, such as 5c concerning the North Shore, situations were reported in which extensive far suburban express bus services made no sense, because of the lack of radial highway facilities. The Western Corridor is different. Express buses will provide superior travel times from many western corridor origins. But the analysis of the proceding section shows that it is inaccurate to think of express bus services being automatically less expensive or more cost effective than existing or improved Commuter Rail. The far suburban areas of the Western corridor are seeking a mix of facilities.

One example (out of many possible) of a logical investment is some level of public participation in a combined express bus/carpool staging area in Natick, near the Mass. Turnpike. A site for 1000 cars has been isolated for further analysis in the CTPS Framingham/Natick Transportation study, located near the Mass Turnpike Interchange #13. This is an example of possible public involvement in support of successful private carrier operations in the Western corridor. Private carrier operations have received only minor attention in this report because of the lack of many opportunities for public intervention. This kind of multi-modal terminal is such an opportunity.

Staff Report #5d:

CAPITAL NEEDS DEVELOPED AT THE CORRIDOR LEVEL: THE CORE

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I. Regional Context

Travel to the core area has been the principal concern of the six corridor studies produced in this series of Staff Reports for the 1976 Revised Program for Mass Transportation. Tables 1 and 2 below summarize in Origin-Destination format the travel patterns between the core and the rest of the region. Table 1 summarizes the trips made in the A.M. peak period to the CBD and to the rest of the core area (definitions of corridors can be found in the Regional Context section of the the Western Corridor segment of this Staff Report). Table 2 presents data not previously published in the corridor reports, showing the A.M. peak period travel from the CBD and the rest of the core area to all destinations.

The flows to the CBD are particularly strong from the South Shore corridor, with about 33,000 trips, followed by the Northern corridor with about 28,000. This tends to support the 1966 PMT's decision to extend rapid transit to these two corridors as first steps in the regional program. However, it should be noted that the strongest single contributor of trips to the CBD is none of the "corridors" as defined in these Tables, but rather the inner communities of the rest of the core area. From these communities, 53,000 such trips are sent to the CBD, emphasizing once more the need to stabilize and improve transit services to the existing riders of the close-in neighborhoods.

The A.M. peak period trips with origins in the CBD and the rest of the core are presented in Table 2. The following sections of this Staff Report, particularly Section III, tend to emphasize the importance of trips made within the core area. Specifically, the area is remarkably self-contained in terms of A.M. trip-making. Of the trips starting in the full core, 72% are destined for other areas within the core. It is noted that 53,000 trips from the non-CBD part of the core end in the CBD. But it should also be noted that 115,000 trips from this area end outside of the CBD, but within the rest of the core.

The sheer magnitude of trip generation in this area is significant. The trips originating in this area during the A.M. peak period comprise 37% of the trips starting within Route 128, and 16% of the region's trips. More importantly, almost half of the transit trips originating inside Route 128 start in this core area.

For the corridors (i.e., "Zones 3-14"), Table 2 shows the relative strength of major outward flow travel from the core to the rest of the region. Those 28% of A.M. core trips with destinations in the corridors make up about 72,000 trips. Outbound trips from the CBD include about 14,000 to the rest of the core

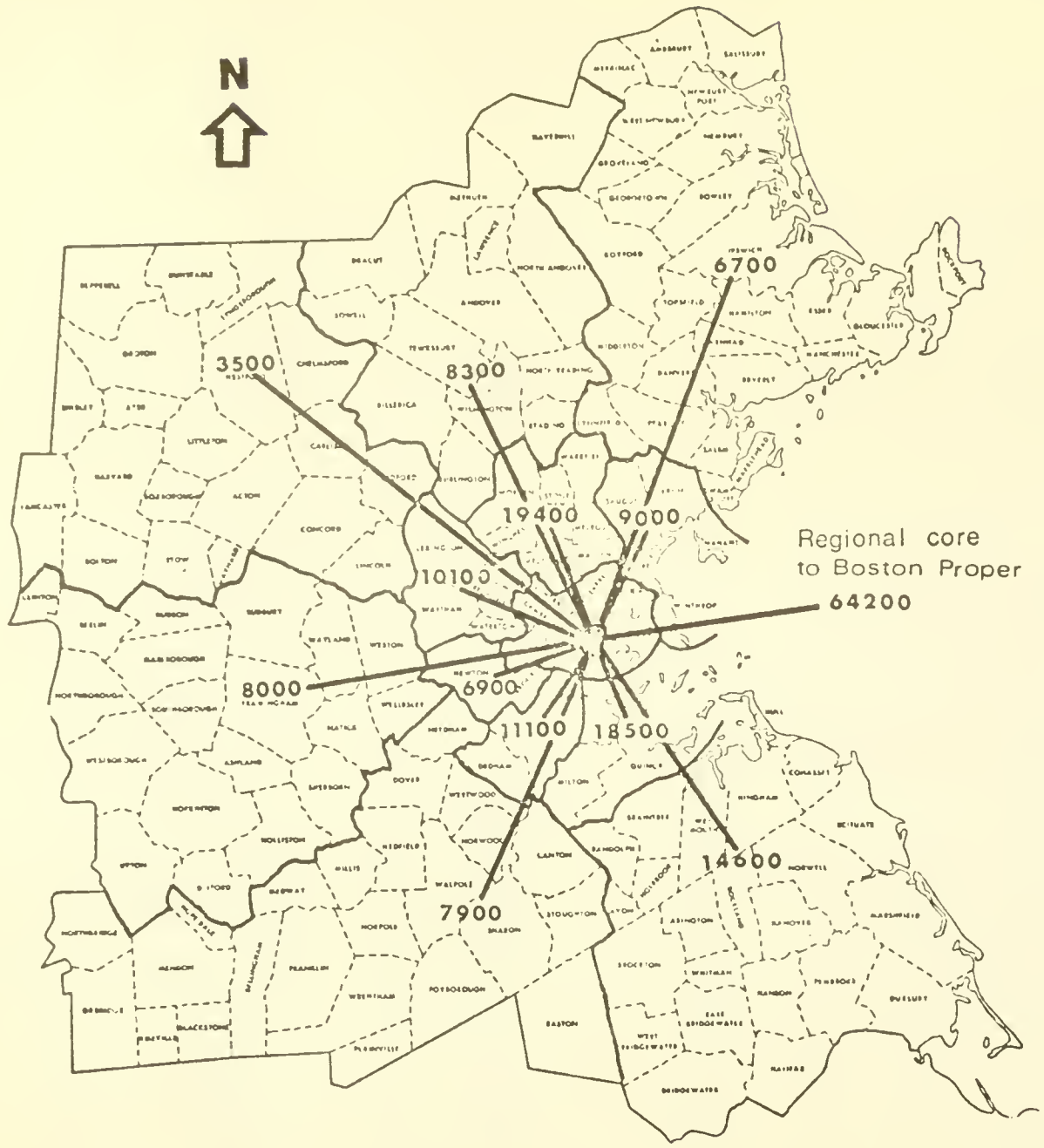
Table 1. Peak Period AM Travel To The CBD, Rest of Core, and Full Core

From Zone:	Total Trips	To CBD	as%	To Core w/o CBD	as%	To Full Core	as%
1- CBD	36296	11082	30.5%	14013	38.6%	25095	69.1%
2- Core w/o CBD	229794	53156	23.1%	115474	50.2%	168630	73.4%
3- N. Shore Inner	60339	9018	14.9%	10812	17.9%	19830	32.9%
4- N. Shore Outer	150538	6689	4.4%	7651	5.1%	14340	9.5%
5- North Inner	103868	19437	18.7%	20049	2.0%	39486	38.0%
6- North Outer	186369	8321	4.5%	8805	4.7%	17036	9.1%
7- NW Inner	90507	10132	11.2%	20745	22.9%	30877	34.1%
8- NW Outer	95384	3499	3.7%	5968	6.2%	9467	9.9%
9- West Inner	45986	6850	14.9%	9689	21.0%	16539	36.0%
10- West Outer	146864	7977	5.4%	9083	6.1%	17060	11.6%
11- SW Inner	57137	11069	19.4%	12749	22.3%	23818	41.7%
12- SW Outer	132898	7898	5.9%	8285	6.2%	16183	12.2%
13- S. Shore Inner	85964	18535	21.6%	18744	21.8%	37279	43.4%
14- S. Shore Outer	187247	14571	7.8%	12493	6.7%	27064	14.5%
Total	1609191	188234	11.8%	274470	17.0%	462704	28.8%

Table 2. Peak Period AM Travel FROM The CBD, Rest of Core,and Full Core

Destination Zone	Trips From 1-CBD	%	External Trips %	Trips from 2-Core	%	External Trips %	Trips From 1 & 2	%	External Trips %
1. CBD	11082	20.5	Internal	53156	22.9	46.3	193725	71.7	Internal
2. Core w/o CBD	14013	38.5	55.5	115474	49.7	Internal			
3. N. Shore Inner	648	1.8	2.6	6191	2.7	5.4	6839	2.5	9.4
4. N. Shore Outer	392	1.1	1.6	2051	0.9	1.8	2443	0.9	3.4
5. North Inner	1683	4.6	6.7	7714	3.3	6.7	9397	3.5	13.0
6. North Outer	891	2.5	3.5	3033	1.3	2.6	3924	1.5	5.4
7. NW Inner	1250	3.4	5.0	9188	4.0	8.0	10438	3.9	14.4
8. NW Outer	158	0.4	0.6	2299	1.0	2.0	2457	0.9	3.4
9. West Inner	938	2.6	3.7	5197	2.2	4.5	6135	2.3	8.5
10. West Outer	486	1.3	1.9	3071	1.3	2.7	3557	1.3	4.9
11. SW Inner	1387	3.8	5.5	5467	2.4	4.8	6854	2.5	9.5
12. SW Outer	477	1.3	1.9	3429	1.5	3.0	3906	1.5	5.4
13. S. Shore Inner	1799	5.0	7.1	9021	3.9	7.9	10820	4.0	14.9
14. S. Shore Outer	1092	3.0	4.3	4503	1.9	3.9	5595	2.1	7.7
	36296			229794			266090		

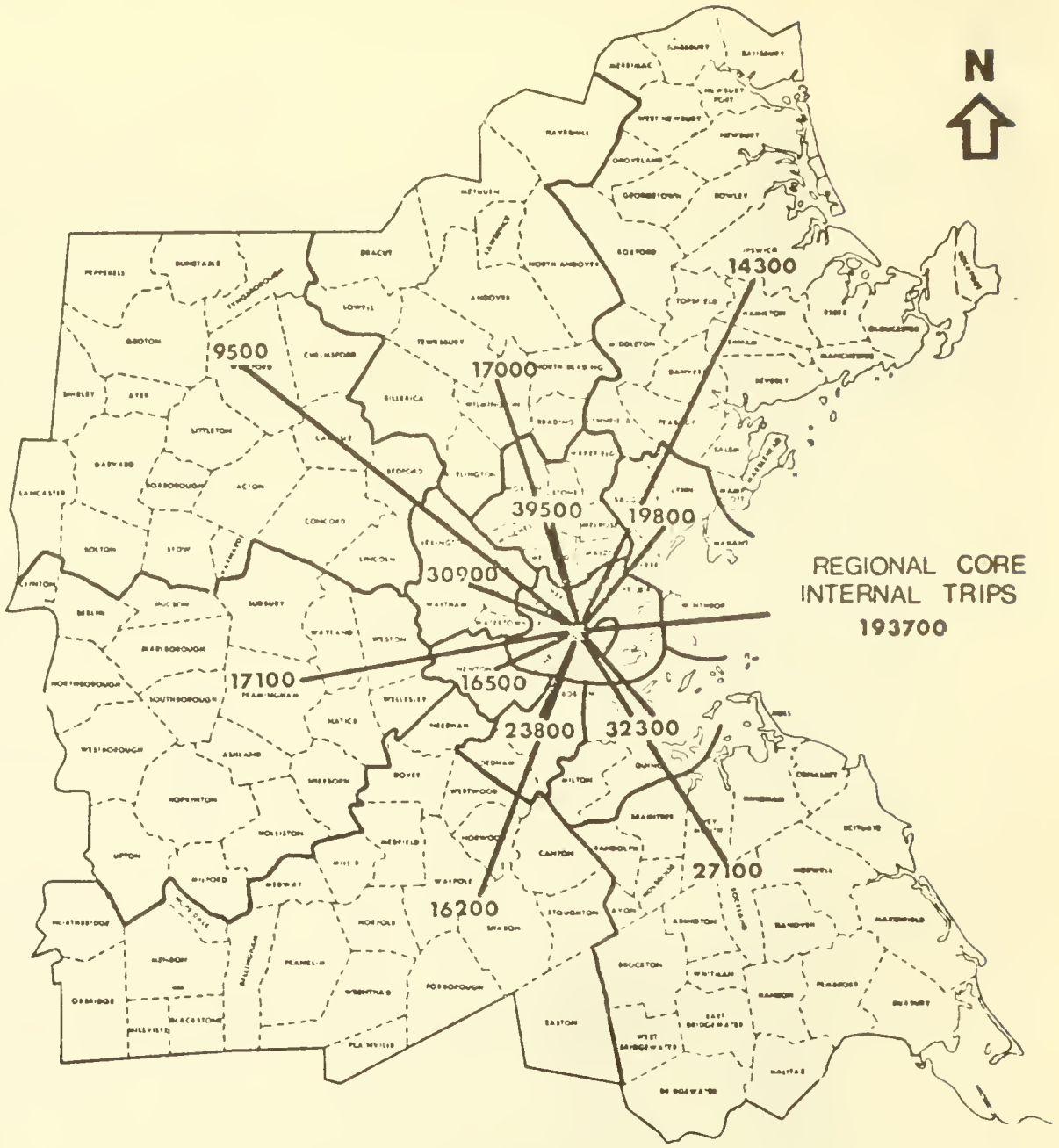
and 11,000 to the corridors. When compared with about 177,000 trips coming into the CBD in that period, the strength of the CBD as a destination is re-emphasized. Similarly, the rest of the core area receives about 145,000 trips from non-core areas during the A.M. peak, while sending only 61,000 trips to non-core areas. The strength of the inward radial A.M. travel pattern may be less strong than in the past, but it still represents the greatest segment of the metropolitan traffic load. Together, from all sources, the CBD and the rest of the core receive about 463,000 trips in the A.M. peak period.



1980 PEAK PERIOD TOTAL TRIPS

TO BOSTON PROPER

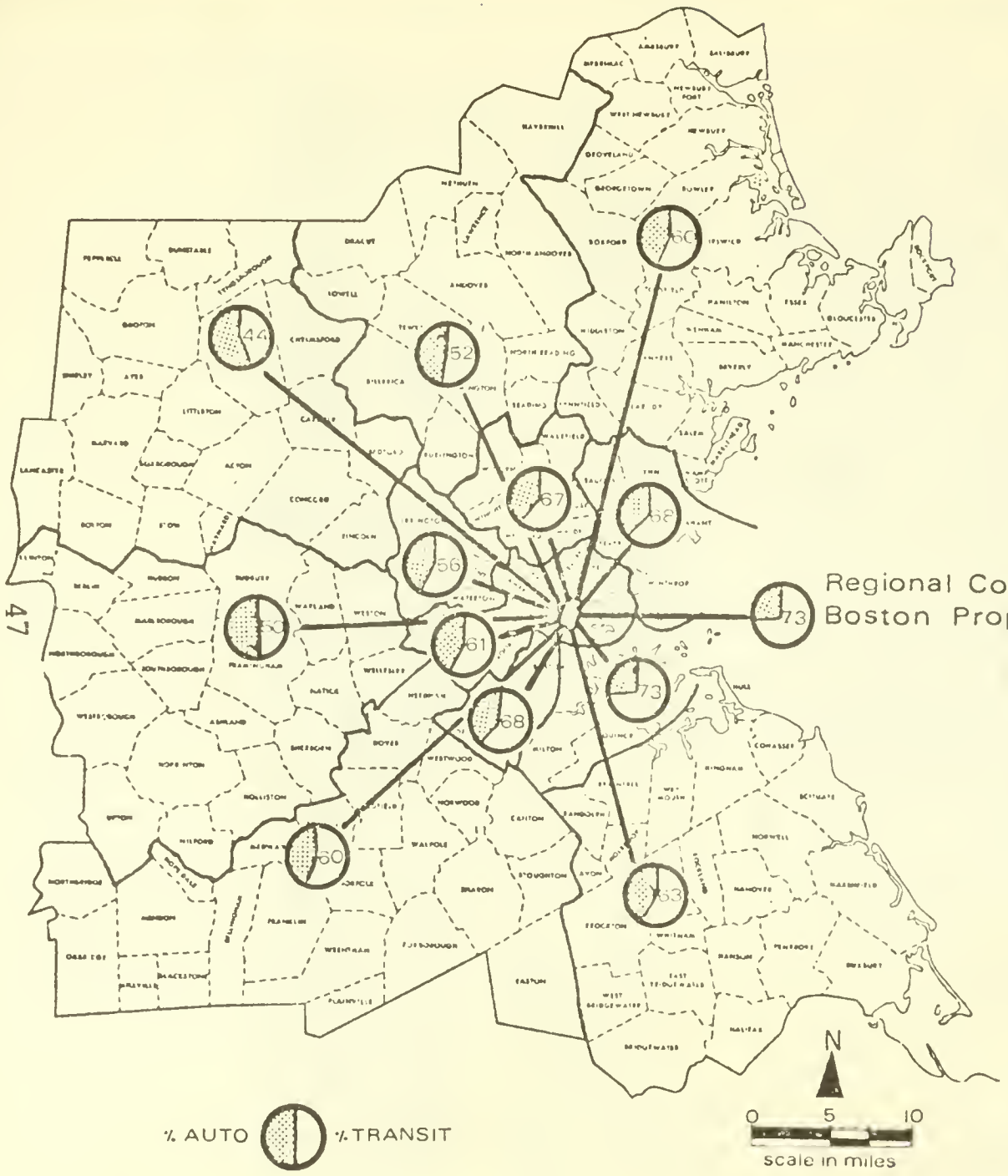
Figure 1



1980 PEAK PERIOD TOTAL TRIPS

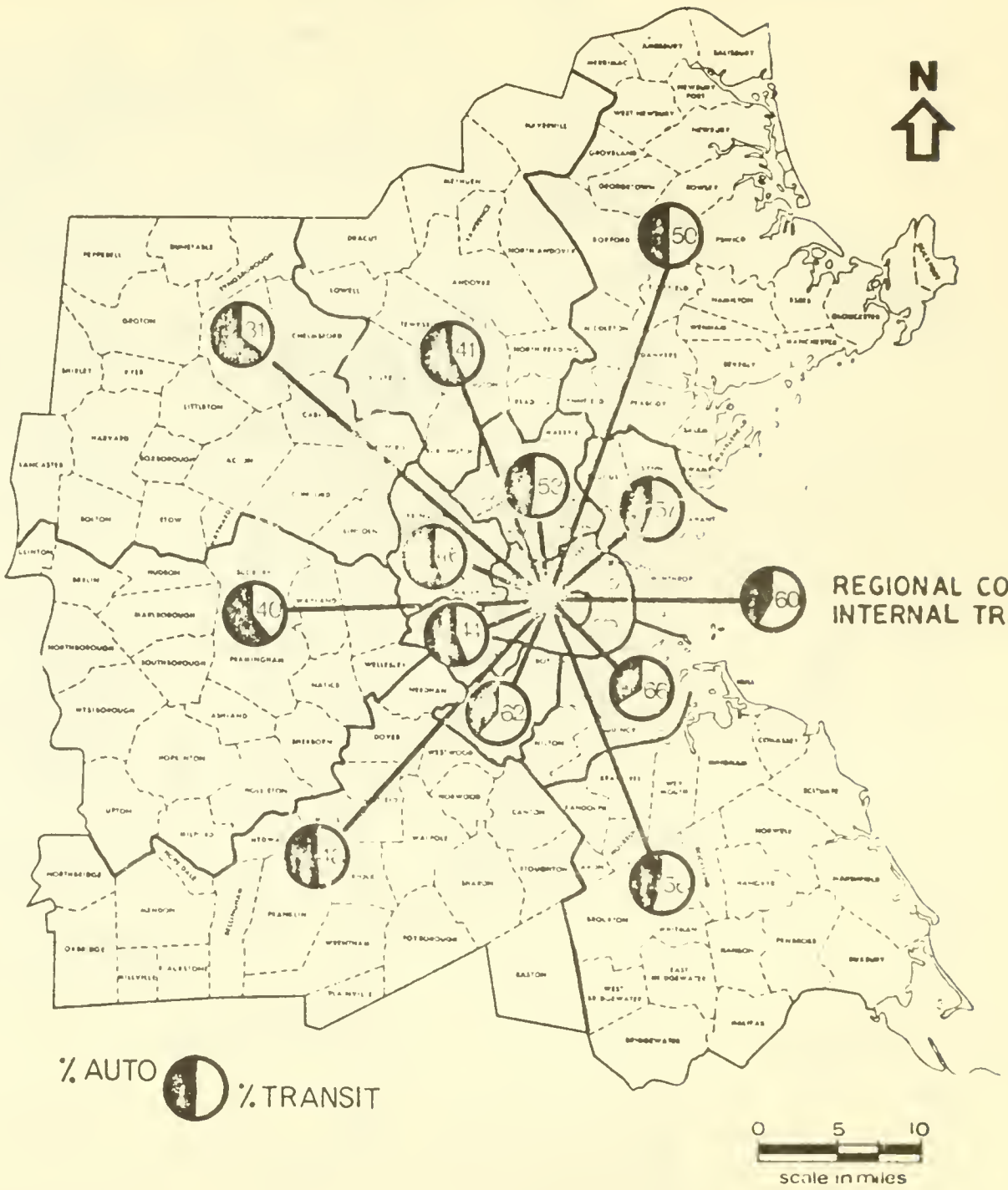
TO REGIONAL CORE

Figure 2



1980 PEAk PERIOD PERCENT TRANSIT
FOR BOSTON PROPER TRIPS

Figure 3



1980 PEAK PERIOD PERCENT TRANSIT
FOR CORE ORIENTED TRIPS

Figure 4

II. Analysis of Existing Conditions

II.A. Central Business District

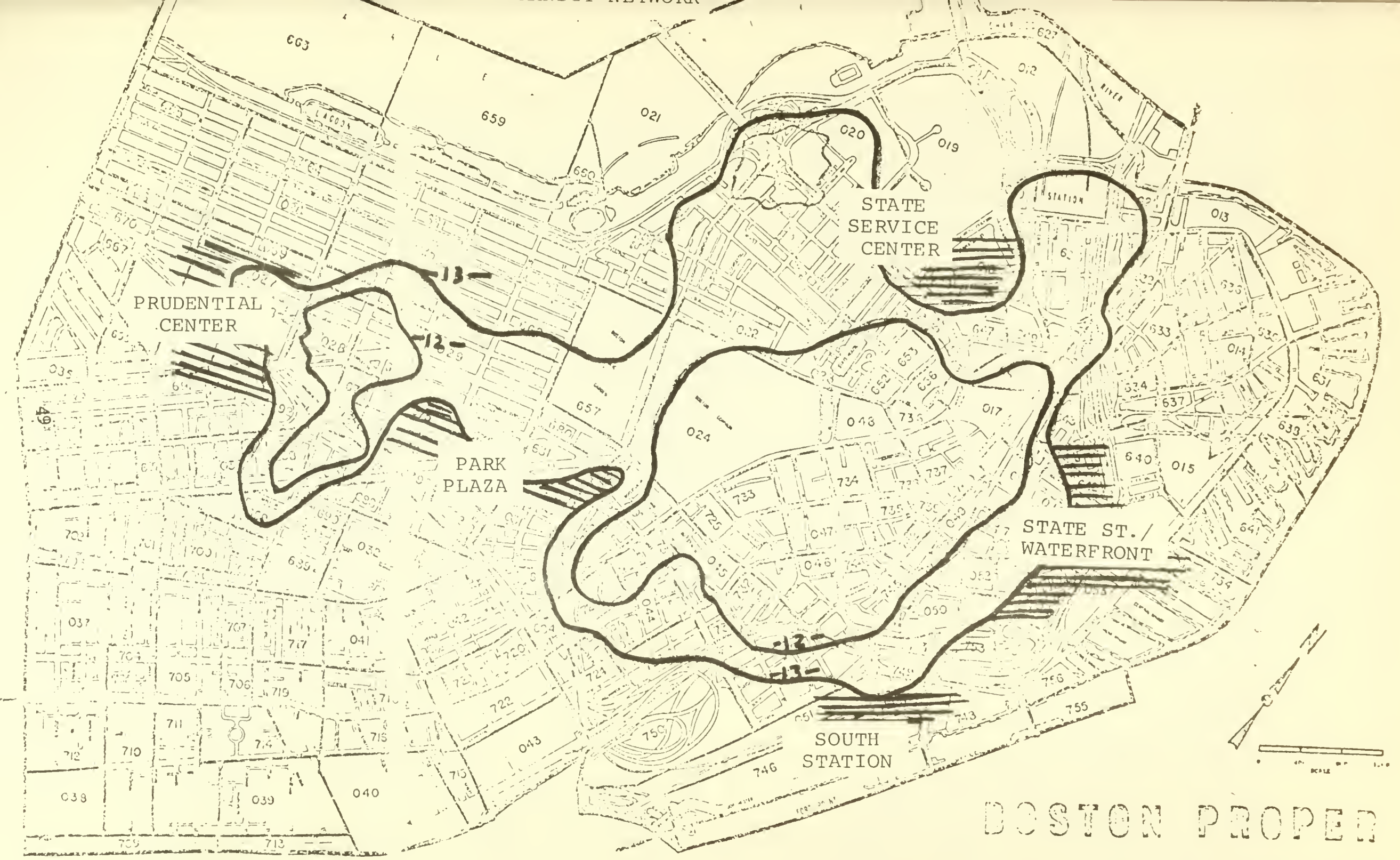
Analysis of the relative levels of accessibility in the CBD can be organized in two formats. In the first, land is examined to determine which zones are better served than other comparable zones. In the second kind of analysis, the separate transportation services themselves are examined in terms of their ability to perform downtown distribution services. Section II.A.1 of this Staff Report presents a brief summary of the relative accessibility levels of the various areas of the CBD, as summarized in Figure 5, below. Then, Sections II.A.2-4 present summaries of the distribution characteristics of the rapid transit, commuter rail, and express bus services. of the CBD. Data concerning the service levels and capacity characteristics is presented in Staff Report #2.

II.A.1. Accessibility by Zone

Through a computerized simulation process, the travel times of all transit trips from cordon points to Central Business District destinations have been modelled for 1980. From this data, it has been possible to calculate the relative level of accessibility for the entire land area of the CBD. This information is summarized below in Figure 5. The purpose of the analysis was to locate zones of major economic activity which could be described as significantly underserved. The analysis revealed that very few major areas could be so described. In specific, it is clear that the Prudential Center, parts of the Park Plaza project, the South Station area, Lower Broad Street, the State Street/Waterfront area and the State Service Center along Cambridge Street can be described as underserved relative to other areas in the proposed 1980 network.

However, with the above important exceptions, the data has not revealed any clear pattern of significantly underserved areas relative to service given the major activity centers. It has not been possible, then, to locate a contiguous string of dramatically underserved destinations which would benefit from a distribution system of their own.

With the data organized in this manner, a median value of zonal accessibility can be determined. The median value is just under 12 minutes of distribution time, with 51.4% of the trips ending in zones with average accessibility better than 12 minutes. Arbitrarily then, we can label those values above 12 minutes as inaccessible, and subject to some kind of improve-



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ISOLINES OF ZONAL ACCESSIBILITY VALUES : 12 and 13 MINUTES OF TRANSIT DISTRIBUTION TIME

ment. This data reveals that zones with accessibility values above 15 receive only about 9% of the CBD trips. On the other hand, 40% of the trips end in zones with accessibility values between 12 and 15 minutes.

The trips tend to end in a relatively small range of zonal accessibility. Fifty-six percent of the transit trips end in zones with average accessibilities of between 10 and 13 minutes. More than 80% of all CBD transit trips end in zones whose accessibility is better than 14 minutes. What is revealed is the relative uniformity of major activity centers in terms of their access by rapid transit in the 1975 CBD system. The isoline which represents the land mass accessible by less than 13 minutes of distribution time reaches from the old financial district just to the east of Post Office Square and covers Back Bay zones beyond Copley Square to the Lord and Taylor area of the Prudential Center. This one category of accessibility (between 12 and 13 minutes of distribution time) is the largest in terms of both number of zones included, and number of trips ending in those zones. Out of 172 zones, 25 have accessibility values between 12 and 13; out of approximately 200,000 trips, 42,460 end in these zones, or 21%.

II.A.2. Accessibility by Mode--Rapid Transit

a. The Red Line. The Red Line is second only to the Orange line in terms of average distribution time. Red Line riders from the Northwest spend an average of 11.6 minutes in distribution, including walk time to their CBD destinations; riders from the south spend 11.1 minutes. For the CBD as a whole, the median distribution time is about 12 minutes. The Red Line from the South distributes 58% of its passengers within the median distribution time, giving it the highest ranking of any CBD service in this dimension. From the Northwest, however, the Red Line distributes only 43% of passengers within the median time. As noted in Staff Report #2, much of this high quality performance is due to the fact that the Red Line alignment enters the CBD at points very close to the major downtown destinations. For riders destined to the Financial District or the retail corridor, the Red Line service is direct indeed. However, it should be noted that for every 100 Red Line trips coming across the cordon line, there are 42 transfers to get to final CBD destinations. Some of these are trips to the Blue Line which take two transfers.

Riders from the Red Line South make about 20,000 in-bound transfers per day to get to their destinations, with about 12,000 transfers by riders from the Northwest. This is the single highest number of transfers in the core network, and implies a critical need for well-designed complementary distribution services. Even in theory, it would not be

desirable to alter the Red Line's downtown alignment. Some 60% of the riders get direct, no-change-of-vehicle service in the CBD. Concepts such as running Red Line vehicles to the Back Bay would cause disbenefit to more passengers than benefit. In short, the simplest statement about the Red Line's downtown distribution characteristics is that the majority of passengers are well-served by its existing configuration, and that a minority must transfer, primarily to get to the Back Bay area, where about 20% of the trips end. The single highest volume transfer movement in the core is the volume from the Red Line South to the various destinations in the Western core area including both the Back Bay and the Fenway Institutional areas. A study done at BTPR showed that, in theory, the optimal point at which to facilitate this movement would be at Broadway station, thereby bypassing the CBD stations for these riders. A distribution shuttle between Broadway and Back Bay, for example, could cut about 6 minutes off the travel time for this movement. The Red Line distributes the majority of its riders well; the quality of service rendered to the rest depends on the effectiveness of supplementary distribution connections.

b. The Blue Line. The deficiencies of the Blue Line downtown distribution have been the subject of considerable planning attention over the last decade, with no clear-cut solution yet determined. Only one-third of the Blue Line's passengers have distribution times within the median value of 12 minutes. Blue Line riders spend about 15.8 minutes, on the average, in distribution time. This is about 5½ minutes longer than the time spent by Orange Line users. Unlike the Red Line, the majority of Blue Line riders have to make a transfer to get to their final destination. This has led to considerable analysis of the possibility of extending the Blue Line tunnel beyond Bowdoin to reach more downtown destinations and network connections. Two of these options are discussed in Section V of this Staff Report, viz., connecting with the Green Line to serve Back Bay, or continuing to a terminal at Charles Station, with a direct transfer to the Red Line.

The underserved desire lines of the Blue Line require detailed examination in the PMT planning process. At the present time, about 5,500 transfers occur at Government Center station, to get to the Red Line and Back Bay. However, a greater number of people are currently disembarking at State station in order to make a connection to the retail core, and points south on the Orange Line. Approximately 6,700 people are estimated to make this connection. The problem issue here is the layout of State Street station serving this strong desire to transfer from the Blue to the Orange Line southbound. It takes about 2½ minutes to make this walk for a fully ambulatory person.

For the elderly or handicapped rider, the connection would take longer.

The largest single destination for Blue Line riders is Washington station. After the 2½ minute walk to the Orange Line platform, the transfering rider waits for the Orange Line connection to Washington station. This is particularly inefficient for most riders making this trip, for the closest platform of Washington station is actually only about 400 feet away from the State platform. Long-term station modernization plans do include the option of finishing this last leg of an underground State-Washington connection. In studies to date, the option of placing some form of moving walkway system to handle this significantly underserved demand has been determined to be theoretically possible, but mechanically very complex. Based on the revealed travel patterns of Blue Line riders, however, it is clear that this type of downtown distribution improvement is worthy of further examination.

c. The Green Line. Distribution service on the Green Line is characterized by excellent geographic coverage, but long travel times for some trips. Of the riders on the Green Line from the west, 93% do not need to transfer to finish their downtown trips; of the trips from Lechmere, about 70% do not transfer, with most of the rest using Haymarket station to transfer to the Orange Line. These low transfer figures show the strength of the geographic coverage provided by the Green Line. However, its overall distribution times are not low, reflecting the geographic fact that the clear majority of Western corridor Green Line riders need to be distributed into the retail and financial district. Thus, the average distribution time from the west is 11.6 minutes--similar to the Red Line even though there are far fewer transfers involved. The slow running times between Lechmere and Park Street make the average distribution time for these riders about 13.6 minutes per trip--only the Blue Line ranks lower in this dimension. The Orange Line from the North will be about 2½ minutes faster in terms of total distribution time than the Lechmere Line, when the Orange Line is relocated to serve the Back Bay.

The Green Line from the west distributes just under half of its riders within the median distribution time for the system. Distribution time to Post Office Square for Western Corridor riders is about 17 minutes, including a 7-minute walk from Park Street. This is indicative of travel times for a major segment of the Green Line riders from the west. In contrast, the growing express bus service from the west is able to enter the downtown system at a point near to these major destinations, and thus minimize total travel time from the west to the traditional downtown.

Because of the excellent geographic coverage provided for the downtown area, the Green Line must be described as well-located for distribution purposes. However, the data does show a significant group of riders who do experience travel times significantly above the median. This data would tend to underscore the decision of the Authority to improve the operations of the existing Green Line by a variety of strategies to lower station dwell times, to improve the regularity of headways, and to increase running speeds to the extent possible.

d. The Orange Line. Little needs to be said concerning the distribution characteristics of the Orange Line when relocated to serve the South Cove and Back Bay areas. Staff Report #2 presented data showing the Orange Line overall to have the best distribution characteristics in terms of average distribution time, in terms of number of riders distributed without a transfer, in terms of the percentage of riders distributed within the median distribution time, and in terms of travel time per direct mile. The only "weak links" that deserve further policy attention are possible connections between Back Bay and Copley, for riders traveling between the West and Southwest corridors; between Washington and Park, for others needing connection from the Green Line to the Orange Line; and the previously mentioned connection between Washington and State.

II.A.3. Commuter Rail

a. North Station. The deficiencies of the Existing North Station B&M station have been documented on many occasions. Most importantly, the placement of a parking lot between the railroad tracks and the railroad terminal has been a cause of considerable dissatisfaction for several years. Because of the track location, transfer times between the center of the B&M platform to center of platform on the Orange Line is over five minutes. EOTC analysis shows that with better interconnection of the two systems, transfer time could be cut to three minutes.

The average distribution time for B&M riders through North Station was calculated by BTPR as 22.9 minutes based on actual travel patterns between North Station and final CBD destinations. In terms of percent distributed within the median distribution time for the system, under 5% of the riders would be distributed in under 12 minutes, using assumptions comparable to the section above.

As noted above, at least two minutes could be cut from the travel times now experienced by pedestrian improvements to the North Station area. Other policy options for the connection include the provision of a free transfer included in the

total price of a ticket.

b. South Station. Actual distribution times from South Station are about 2½ minutes better than those from North Station. Walking times to major destinations are much shorter, but the Red Line is not as effective a trip distributor as the combination of Green and Orange Lines available at North Station. In terms of existing physical conditions, South Station has been in the process of reconstruction for the past several years. What has resulted is something of a stalemate condition, as no improvements in the passenger environment have been made while plans for the final facility are developed. Construction of the Stone and Webster building in part of the passenger waiting area caused conditions to further deteriorate. Reconstruction of the South Station Transportation Center will require some level of Mass Transportation capital participation, as noted in Section V.

c. Back Bay Station. Passengers using Back Bay station have average distribution times of 17.1 minutes, almost 6 minutes lower than North Station. For its users, Back Bay station has the lowest average distribution time of any commuter rail station. The distribution time for a Back Bay user is only 1 1/3 minutes longer than for the average Blue Line rapid transit user. The facility is now owned by the MBTA, and is slated for reconstruction with the Relocated Orange Line. Distribution characteristics for commuter rail users from the West and Southwest will be vastly improved by the relocation of the Orange Line. With a one-minute direct platform connection, CRR users will be able to transfer to the highest quality distribution facility in the core, the Orange Line.

II.A.4. Express Bus

a. Park Square. Although the Park Square bus terminal is located near the centroid of trip-making activity for the CBD, it is poorly located in terms of (1) transit connections, and (2) the major activity locations of either the Back Bay or the traditional core area of the CBD. In a recent CTPS survey of bus riders to this terminal, requests for more downtown distribution was the most common response to questions concerning adequacy of service. The facility is also poorly located in terms of access to the regional expressway system, with buses having to deal with local traffic. The accessibility of the regional bus terminal from the expressway system will be greatly improved when the BRA consolidates major bus services at the new South Station Transportation Center. However, from the perspective of quality of downtown distribution services, it is clear that careful attention will have to be paid to the quality of secondary distribution services from South Station

to destinations other than the retail and financial districts.

b. South Station. The Plymouth and Brockton bus services currently operate from a point at Essex Street and Atlantic Avenue. These services will benefit greatly from the environmental improvement to be created by the reconstruction of South Station as a multi-modal facility. However, the need for supplementary distribution services noted above will also be a factor here.

c. MBTA Express Bus Routing. The MBTA express bus services currently operate to Haymarket station from the North, and to Summer and Chauncy Streets from the West. The Haymarket station site has an average downtown distribution time approximately five minutes shorter than North Station, the other major terminal from the Northern corridors. It is well-situated in terms of its connections to both the Green and Orange Lines. Transfers are necessary to reach the retail and Back Bay areas, and the financial district can be reached by a twelve minute walk.

From the west, MBTA express bus riders are given excellent distribution to the retail and financial districts, which are directly served. However, connections to the Back Bay area remain an unsolved problem. The analysis of increased bus service for the Western corridor, earlier in this Staff Report, pointed out the difficulty of serving both the Back Bay and traditional downtown areas with one service. Some form of supplementary distribution service is needed for those with no option of direct radial service to Back Bay.

II.B. Core Accessibility

In terms of intra-core travel, there have been few significant changes in transit service since the publication of 1966 Program for Mass Transportation. There has been a general increase in the number of local bus routes which serve the CBD directly. To the north, several bus routes serving Charlestown have been through-routed to Haymarket station with the relocation of the Orange Line away from the old Main Street elevated alignment. To the South, the Tremont Street bus has been rerouted to allow a downtown distribution loop to occur, serving Charles Street, Beacon Street, Park Street and Tremont Street. Previous to these routing changes, the City of Boston had insisted on a policy of discouraging buses from distributing passengers directly in the CBD.

The other major intra-core service change has been the creation of the #47 circumferential bus service between Central

Square, Cambridge, and Boston City Hospital. This bus serves a heavily transit-dependent population, with 82% of riders having no car available for the trip. Data presented in Staff Report #1 showed that Student and Medical Support Personnel comprise about 60% of the ridership. Some 75% of the riders are female, far above the system average of about 52% female ridership.

A comprehensive inventory of intra-core services is now being created for inclusion in the PMT. Analysis of the adequacy of the core network is an extremely complex task, with a much wider range of desire lines than found in the corridors. Section III of this report describes a process which examines the potential demand for better direct interconnection of the activities of the full core area. Demand unmet by the existing core transit system is revealed in the following section for Charlestown, Somerville, Cambridge, North Brookline, and the inner residential neighborhoods of the City of Boston. The demand data presented for possible improved intra-core transit service should be seen as a first step in a comprehensive analysis of the adequacy of the present and future core transit systems. The CTPS Circumferential Work Program has been designed to create a program of phased incremental improvements for this study area. The work program specifically rejects the concept of focussing on the design details of a possible capital-intensive facility for implementation in an uncertain future. A complete analysis of demand and service level for intra-core movements will be undertaken in the CTPS Circumferential Study.

III. Demand for Core Distribution

III.A. Purpose of the Analysis

This Staff Report is concerned with a wide variety of possible improvements to the core transit system above and beyond the network already in place. Section II of this Report was concerned with the service characteristics of the existing (and committed) system. This section is concerned with travel patterns not currently well accomodated by the existing system. To support this kind of analysis it is not sufficient to examine an Origin-Destination trip table which describes the magnitude of all flows within the study area. Rather, what is needed is a methodology which defines the transportation flow that could be best handled by some kind of supplementary core distribution facilities.

Based on core distribution studies initiated during the BTPR, the PMT planning process has devoted considerable technical and policy attention to possible transit improvements in the center of the regional network. Demand for core distribution to supplement the committed core network has been modelled using detailed computerized transit simulation techniques. This Section of Staff Report 5d presents a brief summary of the pattern of demand for core distribution services, on a community by community sub-area basis. The demand data here presented should not be confused with comprehensive origin-destination data. Rather, the trips shown in this section are only those trips which would be best served by supplementary facilities. This section of the Staff Report 5d contains eight capsule summaries of revealed demand for improved core distribution services, organized by geographic subarea. It examines distribution difficiencies of the existing transit network, and describes the characteristics of demand for additional services in terms of the service needs of the eight subareas.

III.B. Subarea Analysis of Distribution Demand

This study is concerned with the failure of the existing transit system to provide certain distribution services within a radius of about 2 miles from the center of Boston. The services under study can be divided into two major categories: distribution to the downtown area, and distribution to the circumferential study area. The phase "core distribution" is used to describe services which cover both CBD and circumferential movements.

In order to analyze the potential demand for a vastly improved core distribution transit system, a hypothetical network was created which provided maximum transit coverage for the full core area. Every station in the hypothetical network was connected with every other station by direct, no-change-of vehicle service. The network simulated high quality transit service inter-connecting 42 stations with 135 scheduled vehicle routes. A major problem of previous core and circumferential analyses has been the necessity to rely on transit trip tables comprised of trips computed for networks with a serious lack of circumferential and other distribution services. The hypothetical network used in this study has made possible the creation of new transit trip tables reflecting transit tripmaking over a nearly ideal core network. Within certain methodological constraints, (i.e., lack of trip generation sensitivity) the data represents a reasonable statement of maximum desire for transit services throughout the core area.

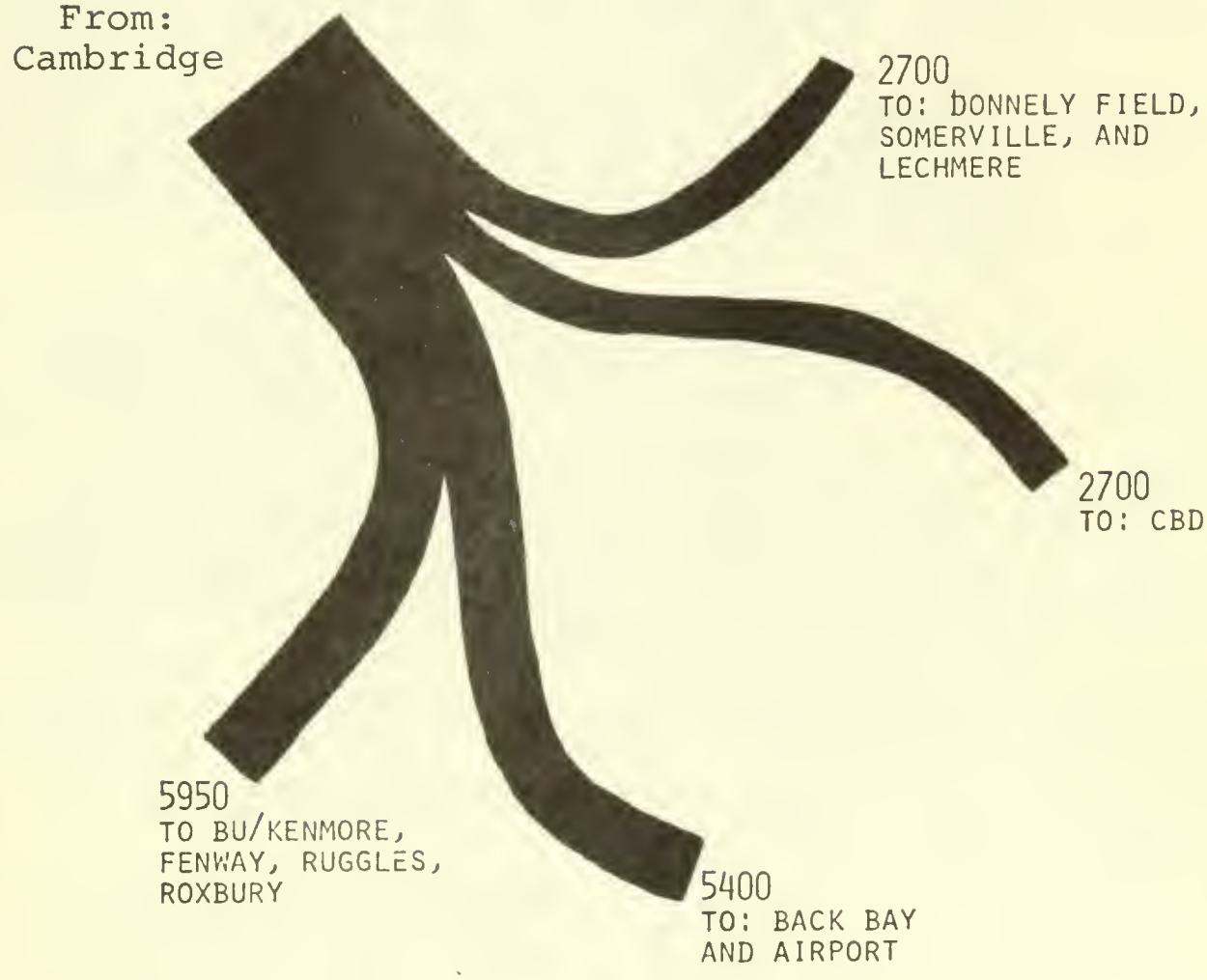
The Concept of Demand. There is no such thing as "a demand" for transportation. There is a specific level of demand responding to a specific level of supply. In this study, optimal attainable supply was modeled for the study area. The term "demand" in the following subarea analyses refers to travel patterns by transit if the full hypothetical network were in place. "Demand" which is constrained by the realities of technology and investment is utilized in project analysis contained in Section V of this Staff Report.

The sketch diagrams accompanying the eight demand summaries describe the desire for transit movement above and beyond that which is supplied by the existing transit plus a relocated Orange line from 128/Needham to Oak Grove in Malden, and a subway surface line to Dudley Square within the study area, as well as Red line extensions to Braintree and Alewife via Davis Square. For each subarea, the data presented shows the volume of movement on the full core hypothetical distribution network as if it was in place. Therefore, the data reveals the demand for core distribution services over and above the existing system, rather than total O-D desire lines.

III.B.1. Subarea Analysis: Somerville

Figure 6 presents a schematic description of the demand for new distribution services from inner Somerville. Even with the excellent downtown coverage of the hypothesized core distributor, the majority of Somerville riders continue to choose the inbound Orange line service from Sullivan Station. Although demand from the area is predominantly radial, Figure reveals a significant latent demand for better distribution to non-CBD destinations.

DEMAND FOR CORE DISTRIBUTION FROM SOMERVILLE
AND SULLIVAN STATION
figure 6



DEMAND FOR CORE DISTRIBUTION FROM INNER CAMBRIDGE

Figure 7

This analysis sought information on potential stations in the inner Somerville area. Stations were considered at Sullivan Square, Union Square, Washington Street at McGrath Highway, and the City Hall/High School site on Highland Avenue. The strongest of these facilities proved to be Union Square, with 3,560 boardings to the core distribution network. Demand for 1,700 riders, mainly walking was discovered for City Hall area. The Washington Street station, with 2,280 boarders performed two functions. First, it collected about 1,000 walk-ins. Second, it provided a transfer point for commuter rail riders from the New Hampshire division service to Winchester and Woburn which had the effect of raising New Hampshire division patronage by 26 percent.

A circumferential distributor can be satisfactorily connected to Somerville's excellent feeder bus network by placing circumferential facility stations at both Union and Sullivan Squares. With this investment, virtually every major Somerville bus line is connected with "cross town" express transit in addition to radial rapid transit. Such a Union-Sullivan alignment would allow the addition of a Washington Street station at a marginal cost equal to that of the station alone.

Figure 6 shows that about 2,500 riders have demand for movement covered by the proposed circumferential facility, from the three Somerville stations included in the hypothetical network. The estimate of similar demand from a Sullivan station is 2000 riders, about half of whom come from Orange Line North. An additional 500 Sullivan riders are bound for Somerville stations.

It is clear that demand handled by a circumferential transit facility is not the highest transit priority for eastern Somerville. If vehicles on a full core distribution network served eastern Somerville, 4,200 riders would use them to make essentially radial trips, while 2,500 would use them to reach Cambridge, BU-Fenway, Huntington, and Roxbury areas. The 4,200 radial trips on the hypothetical distribution network are in addition to 5,000 Sullivan inbound boardings on the relocated Orange rapid transit line.

Although circumferential demand is secondary in importance to Somerville, the combined demand of 2,000 from Sullivan/Orange with 2,500 from the three Somerville stations is significant at over 5,000 riders.

III.B.2. East Cambridge

Demand for supplemenatary core distribution services was found to be low throughout the inner East Cambridge area. Lechmere station received only 2,400 riders for the combined radial and circumferential services of the core distribution network.

Based on available land use and travel data, First Street East Cambridge area does not seem to have the transit trip making characteristics to justify major new service to the area. However, if major regionally oriented land development were to occur in the "Cambridge Parkway" area and/or in the rail yards to the immediate west of Bunker Hill Community College, the consequent transportation demand could be altered radically. In this situation a core distribution transit facility would be desirable if integrated into the developments themselves.

III.B.3. Subarea Analysis: Central Cambridge

Demand from the Central Cambridge area was determined by testing five stations in the area, one in the Kendall Redevelopment area, Broadway at Hampshire Street, Central Square (Red Line), MIT/Mass Ave., and Southern Cambridgeport.

This area is served by excellent radial transit, and the main underserved demand revealed is for circumferential service, and distribution to the Prudential/Back Bay area. Demand for service to the retail and financial districts that would use a mode other than the Red line is neglibible. On the other hand, service from Central Cambridge to Northeastern, Prudential Back Bay station and the Insurance district would carry about 4,900 inbound riders daily, as shown in Figure 7 .

This extended downtown distribution is not as important as the 8,600 trips desiring purely circumferential distribution. Predictably, the demand to the south is just about twice the demand north to Somerville and Lechmere. Between 9 and 10 thousand Red Line riders desire service from a distribution facility, with nearly 3/4 approaching the area from the west.

III.B.4. Subarea Analysis: BU-Kenmore Area

The BU-Kenmore area displays one of the region's strongest desires for new core distribution services. The four stations tested in the hypothetical network study together have more than 21,000 passenger boardings, with 18,000 trips going out of the subarea.

Figure 8 shows that demand for circumferential services are fairly evenly balanced with 4,900 to the North and 5,700 to the South. As the stations are almost entirely in the prime Green Line service area, it is logical that unmet demand for distribution for the Back Bay insurance district so well served by the Green Line stations is virtually negligible. What is revealing is the demand for services to the center of the financial district, and the North Station area. About 5,200 trips are assigned to the distributor destined to P.O. Square, an area of heavy western corridor destinations in which the long Green line running times are a significant service impediment. Significant diversion to P.O. Square station was expected, but the magnitude of the volumes to the state, Haymarket, and North Station areas serve to emphasize a serious deficiency in existing Green line service.

While the absolute magnitude of presently underserved demand to far CBD destinations is revealing, so is the data concerning demand to nearby subareas. The data shows a volume of only 810 between the four stations of the BU-Kenmore area to the 3 stations of the Fenway Hospital area. The Relocated Orange line corridor, Replacement Corridor and Red Line corridors, together receive 4,900 trips from the Kenmore-BU area, showing the significant regional nature of these trip ends.

The absolute strength of each of the stations tested must be noted. The perceived lack of non-residential trip ends in the Peterborough/Queensberry neighborhood might lead to an initial design decision to bypass the area. The revealed demand for a 4,700 boarding station reverses that initial evaluation. By way of comparison, the highest station in the Hospital area attracts 3,400 passengers a day to the core distribution network. This volume is similar to many stations which have transfers from other transit services, which this station does not. Among non-CBD areas with no direct rail transfer, it ranks with Grove Hall, Boston City Hospital, and Northeastern respectively. Additionally, the bordering stations, Fenway and Kenmore, remain strong, at 8,550 and 4,990 riders.

In terms of latent demand, the case for some service to the Queensberry area, and through Kenmore Square is strong indeed.

III.B.5. Subarea Analysis: Fenway/Hospital Area Stations

The Fenway/Hospital area proves to be one of the rare areas where demand for circumferential movement is greater than demand for radial movement. In the hypothetical network

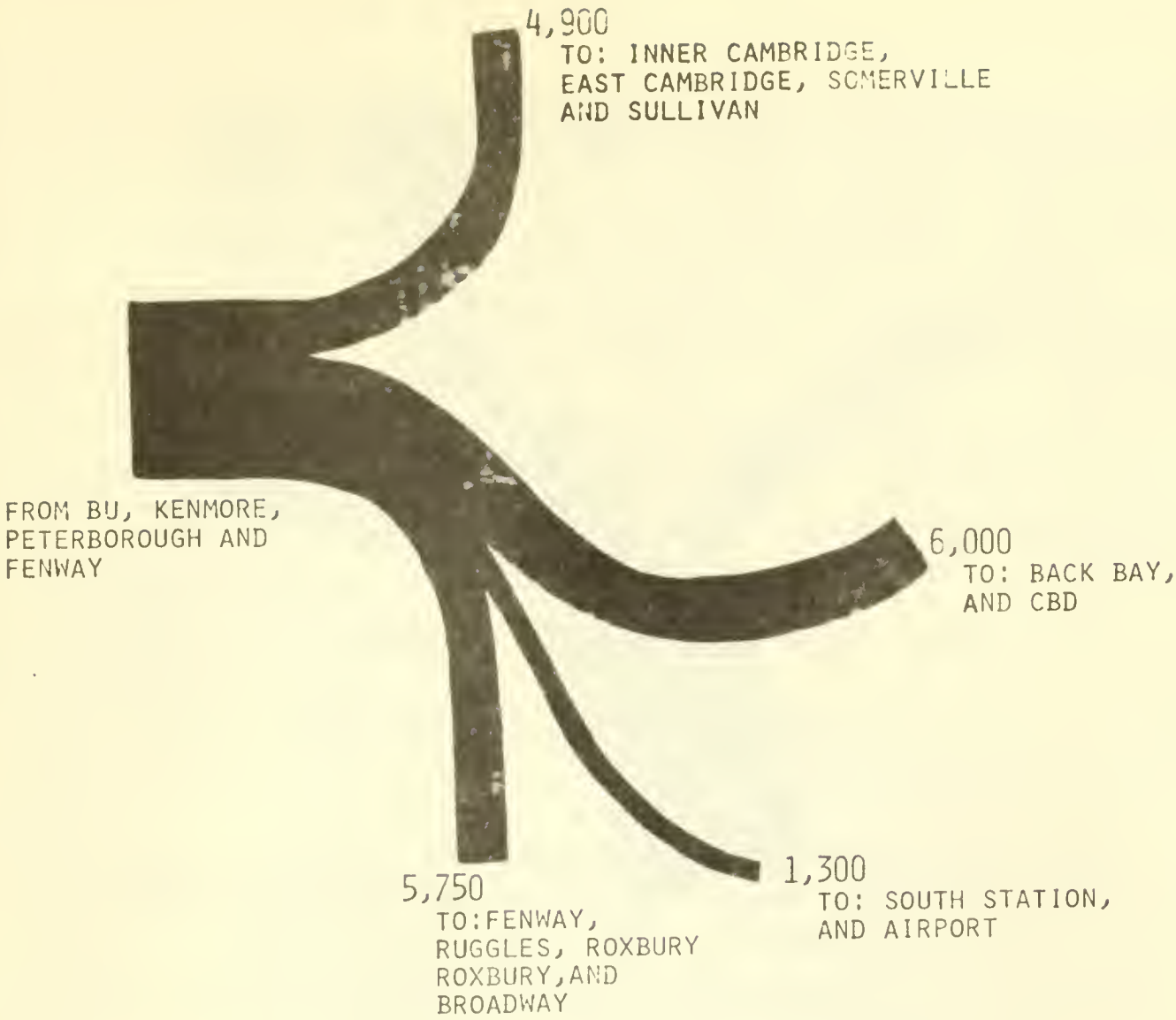


FIGURE 8: DEMAND FOR CORE DISTRIBUTION FROM BU/KENMORE

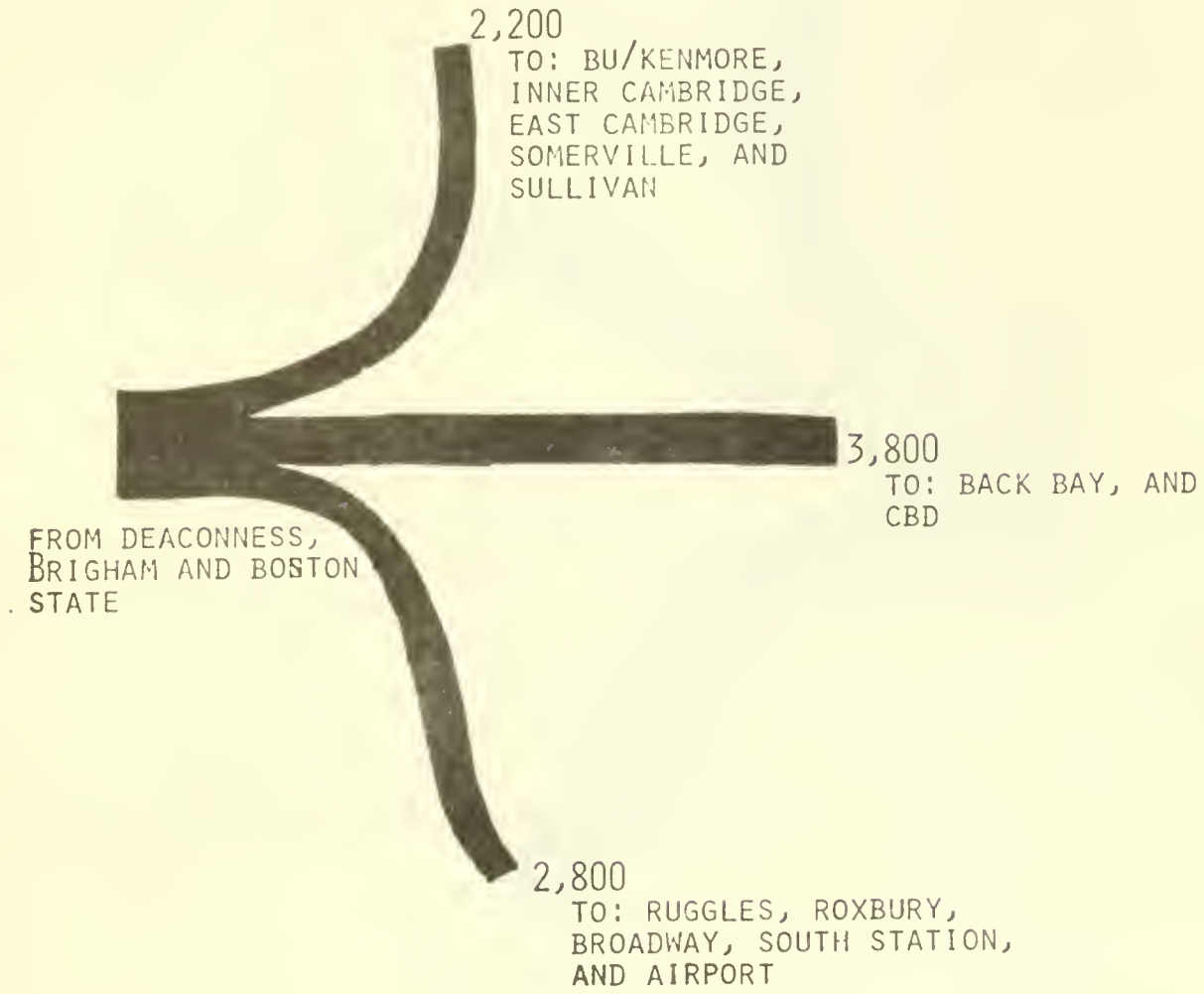


FIGURE 9: DEMAND FOR CORE DISTRIBUTION FROM FENWAY HOSPITALS

the three hospital stations had direct service to the North and South over circumferential routes, and directly to downtown stations. For the purposes of this test only the Huntington Line was assumed replaced by links of the core distribution network. Demand from the three stations to Back Bay and the rest of the CBD was 3,830 riders, while circumferential movements totalled 5,020 riders, as shown in Figure 9.

The demand revealed for the three proposed stations, which attract 3,400 (Brigham), 3,180 (Boston State) and 2,940 (Deaconness/Beth Israel) supports the general concensus that sufficient demand exists for some additional circumferential connection.

III.B.6. Subarea Analysis: The Replacement Corridor

Staff Report 5d has outlined some of the possible alignment options for Roxbury replacement service. The nature of that demand is discussed here.

Examination of origin-destination tables shows that demand from the Lower Roxbury, Roxbury, North Dorchester zones is overwhelmingly radial in nature. The tables show about 10,900 trips ending in the CBD, South End and Charlestown. By contrast, the number of trips ending in the Fenway, BU-Kenmore, Cambridge and Somerville is about 3,000 per day. This data mitigates against a decision to route Replacement Corridor services to the Northwest to the exclusion of downtown service. These numbers represent pure desire lines, and do not take into consideration that good radial service exists on the periphery of the replacement corridor, while satisfactory circumferential service does not presently exist. The question is legitimately raised where those who would board a Roxbury Replacement transit line actually want to go. Assuming that many radial riders to downtown will continue to use both the Red and Relocated Orange lines where is the primary destination area for those served by a replacement facility?

The hypothetical network included replacement corridor service to Grove Hall. Direct transit service was tested for circumferential movement, and for radial to downtown movement. Figure 10 shows the loadings on the hypothetical network north of lower Roxbury station. Given the fact of excellent radial transit service to the east (Red) and to the west (Orange) of the Warren Street segment, demand is less overwhelmingly radial than the initial O-D table showed; and yet demand from the facility to downtown (50 percent) is more than double the demand (23 percent) to the Fenway, Cambridge, Somerville, and all transit connections which would be made over these links.

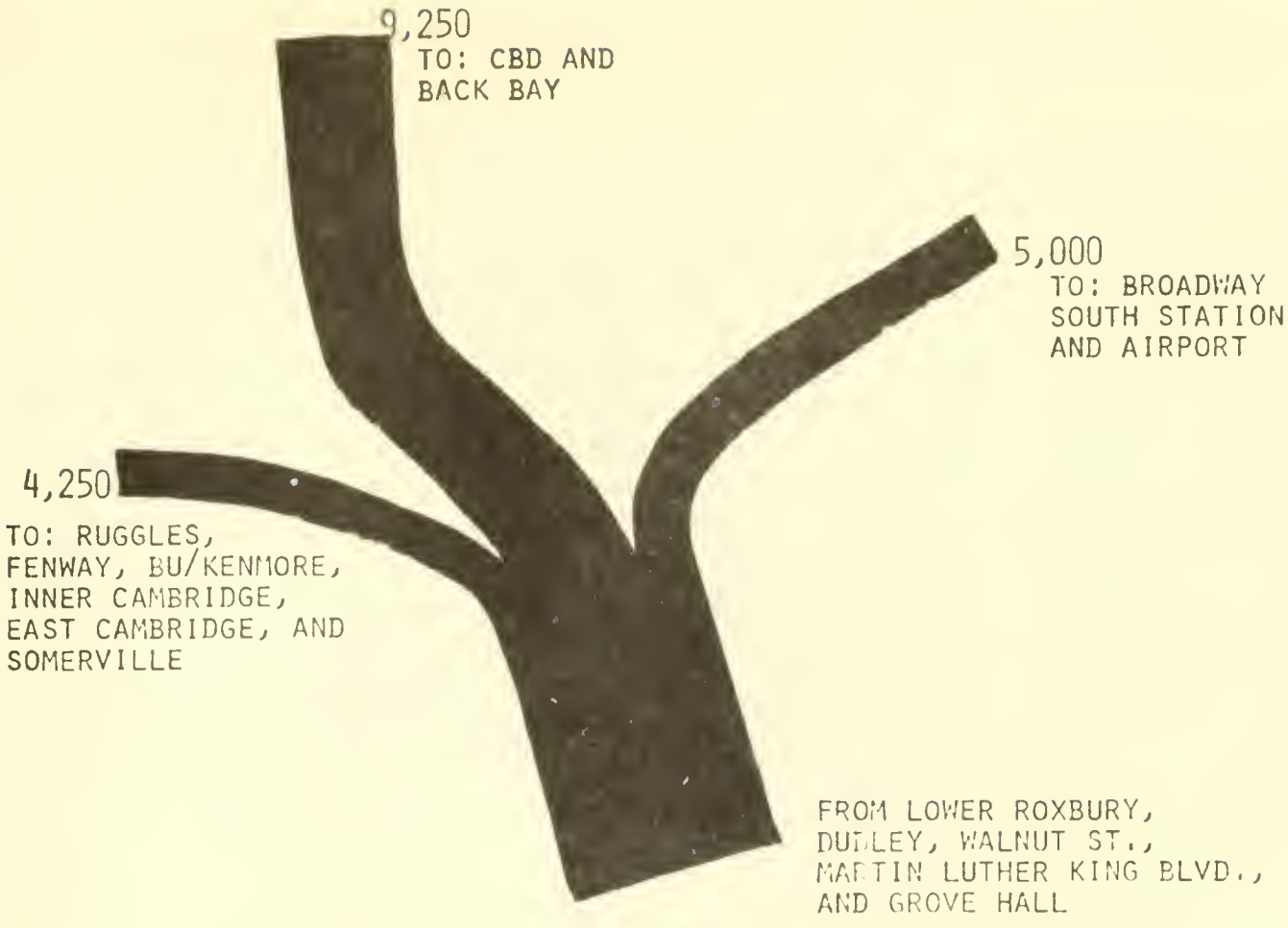


FIGURE 10: DEMAND FOR CORE DISTRIBUTION FROM REPLACEMENT CORRIDOR

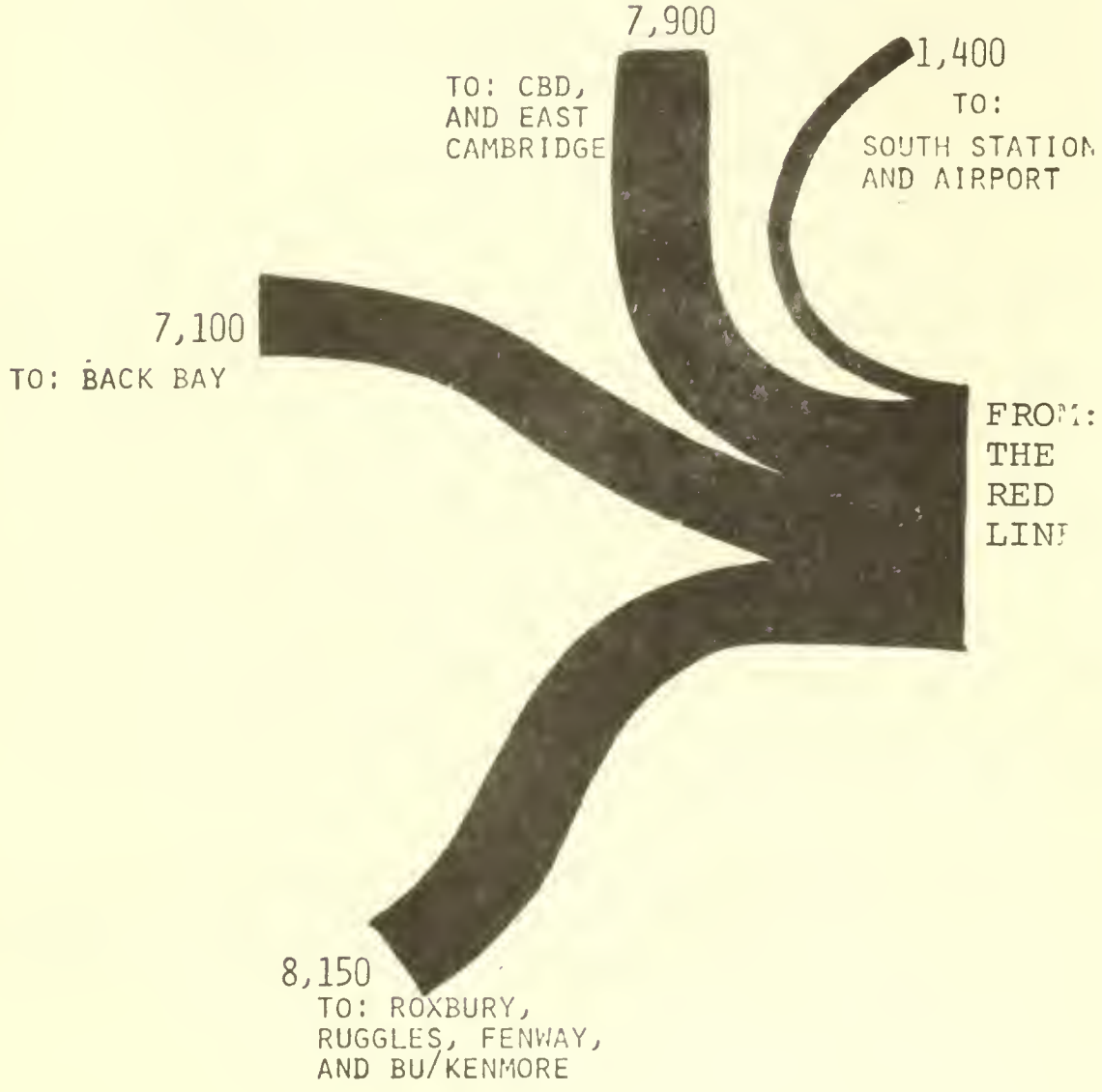


FIGURE 11: DEMAND FOR CORE DISTRIBUTION FROM BROADWAY STATION

When organized in this manner, the data reveals the importance of circumferential connection between this area and the Red Line to the east. Examining destinations north of Lower Roxbury Station, the data shows that 27 percent is making a "right turn" towards the Red line while 23 percent are making a "left turn" towards Fenway, BU, and Cambridge. If certain trips (mainly cross-harbor trips) are removed from this routing, passenger flow from the facility are evenly divided between the direction of Boston City Hospital and the direction of Ruggles Street. The essential policy information here is that "cross town" express transit demand cannot be simply expressed as a matter of better service in the direction of Cambridge. The revealed deficiency in non-radial network performance involves poor linkages to critical points of network interconnection. Based on these brief observations of replacement corridor demand, the importance of connectivity with the Red line must be acknowledged in circumferential planning.

III.B.7. Subarea Analysis: The Relocated Orange Line

Riders on board the Orange line have only minor need for supplementary distribution. Approximately 33 percent of Orange line riders seeking supplemental transit distribution are bound eastward (right turn) and 66 percent westward (left turn). Demand for a supplementary mode to reach downtown stations is almost negligible.

III.B.8. Subarea Analysis: Red Line South

More than any other element of the region's transit network, the Red line is in need of complementary distribution services. This statement is true relative to its downtown distribution deficiencies as well as circumferential distribution needs. Given that the volumes from the southern Red lines are projected to exceed those from the Northwest, the interchange between the Red line south and the distribution network logically appears as the most important station on the system. The demand for improved distribution from inbound Red line trains from Ashmont and Braintree is about 15,000. This compares with 7,000 inbound riders from the Northwest who would choose improved distribution services if provided at Central Square, the second highest potential transfer movement appearing in the network. The summary schematic is presented in Figure 11.

Examining the demand from the South Shore line, it is significant that of the volume on inbound trains, 42 percent have desire lines which would be accommodated on an improved

core distribution network. This data is totally consistent with the summary observation of BTPR's Downtown Distribution study (January 1972) which pointed to Broadway Station as the optimal intercept point for 40 percent of Red Line tripmakers.

The Red line in contrast to the Orange Line-shows a significant need for core distribution services. Several different categories of demand for supplementary services exist from Broadway. Most importantly are the more than 8,000 trips destined for the City Hospital, Roxbury, Hospital Loop, and BU-Kenmore areas. This demand is most significant, perhaps the largest single identifiable demand for circumferential movement. Phrased differently, the Red line south will be the single largest contributor to volumes along the proposed circumferential transit facility.

IV Projects in Advanced Development, or Under Implementation

IV A. Projects Implemented Since 1966

The most significant core project which has been under implementation since 1966 is the Station Modernization program, as described in Staff Report 3. The Program is divided into four phases, two of which have been funded. Phase I is now complete. It included modernization of fifteen stations on the Green Line and all three rapid transit lines as well as porcelain enamel signing at 26 other stations. Phase I is now complete. It included modernization of fifteen stations on the Green Line and all three rapid transit lines as well as porcelian enamel signing at 26 other stations. Phase II stations are now in engineering and some construction. They include modernization of Park, Washington, Ashmont, Essex, State, Haymarket, Shawmut, Science Park, and the stations on the Mattapan trolley line. The Phase III and IV program and the projects to be funded are described below. In the core area, Phase III includes South Sta., Kendall, Central, Broadway, Washington, Essex, and State, stations and will cost about $22 million for all stations. Phase IV will include Andrew, North Station, Symphony, Auditorium, Boylston, and Lechmere stations in the core area at an estimated cost of $13.5 million.

Since 1966, other capital programs have included a major structural and cosmetic refurbishment of the Authority's Green Line Elevated Structure from the North Subway Portal to Lechmere Station, a distance of 1.1 miles and crossing the Charles River in the vicinity of Science Park Station.

IV. B. Projects in Advanced Development

IV. B. 1 Huntington Ave Reconstruction to Brigham Circle

The Massachusetts Department of Public Works is now preparing final construction plans for roadway and transit improvements along Huntington Avenue. These improvements will include the upgrading of the MBTA trolley car right-of-way as well as roadway design, traffic signalization, sidewalk reconstruction, street lighting and general landscaping. This project will be implemented in two phases with Phase I including the portion of roadway from Harcourt Street to Gainsborough Street and Phase II including the portion of roadway from Gainsborough Street to Fenwood Road (Brigham Circle). Phase I is also mentioned in the project description for City of Boston street improvements.

The final implementation details of this program, including level of MBTA capital participation are now being negoitated.

In addition to this project, the Authority is currently cooperating with the city to rebuild the tracks in Center St., Jamaica Plain. No capital funds have been used on this project.

IV B. 2. North Station Pedestrian Improvements

This project could be divided into two elements: Phase I would provide an underground pedestrian passageway from the North Station commuter rail platform area to the mezzanine level of the new Orange Line station at North Station; Phase II would extend the railroad tracks approximately 300 feet to a point close to the North Station building.

This project would provide benefits to present transit users by reducing the walking distance to and from commuter trains, and by eliminating the necessity to cross Causeway Street to reach the Orange and Green Line trains. Either part of this project could proceed without the other, with either phase implemented first.

The cost is $3.5 million of which $2.8 million is for the passageway, and .7 million for extension of the railroad tracks.

IV B. 3. South Station Transportation Center

This project would construct part of the South Station Transportation Center now under development by the Boston Redevelopment Authority. The project included in this program includes: the reconstruction of tracks and platforms for commuter trains, the construction of loading and unloading facilities for commuter buses, and two-thirds of the cost of constructing a new concourse.

Improvements to the Red Line rapid transit station under South Station are included in Station Modernization III. At present, the estimated costs for the commuter rail, regional express bus and RT stations modernization is estimated at $19 million.

V. Core Projects in the Planning Phase

V.A. Green Line Options

V.A. 1. Huntington Ave - Brookline Village Connection

A proposal has been included in the previous TDP for a connection between the Huntington Avenue - Arborway Trolley Line and the Riverside Line at the Brookline Village Station. This connection would provide for distribution of Riverside Line riders into the Medical Area adjacent to Huntington Avenue by a transfer location at Brookline Village.

The alignment for the connection, if accomplished at grade, would be located on New Pearl Street (a part of the Brookline Redevelopment Project) with the transfer station located within the street right-of-way adjacent to the existing Brookline Village station. Trackage would be provided for access from Brookline Village through New Pearl Street, intersecting Brookline Avenue at a new signalized intersection and crossing around a narrow parcel, which has been developed by the Redevelopment Authority to reach the Riverway-Route 9 grade separated intersection. At this location, the route would be located in the center section of Route 9 to align properly with the existing trolley tracks which it would join. At the intersection of Huntington Avenue and South Huntington Avenue, a full -y- between the new connection and the existing Huntington Avenue Green Line would be constructed to permit service into the medical area or south to Jamaica Plain. Connecting track at South Huntington Avenue and Brookline Village would be constructed to permit trolley vehicles to reach the Green Line maintenance facility being constructed at Riverside terminal.

Costs. The approximate cost estimate for this project is $2,000,000, not including the right-of-way and property acquisition costs.

Analysis of this project is continuing, particularly to ascertain its impacts on headways for the rest of the Arborway service. Possible operations schemes are being prepared at this time which will allow traffic forecasts to be made for this project. However, there is serious doubt as to the physical feasibility of the project given the location of the redevelopment activity which has taken place in the last year. Analysis will continue to determine whether the project should be included in the PMT.

V.A. 2 South Huntington Track Relocation, between Brigham Circle and Heath St.

The revised PMT will address the issue of improving light rail rights of way presently operated in streets with no protection for the transit vehicles. At present, the Arborway service between Northeastern and Heath Street has the highest level of accidents per train mile of any surface operation. For example, on the outer portion of the Boston College line, there are 8,250

miles for every one accident. The Arborway Line from Brigham Circle to Heath Street has one accident every 2,000 train miles. Because of an unsatisfactory track layout at Northeastern, the inner section has an accident every 1240 train miles. The need for better train separation from street traffic is overwhelming for this line, particularly in terms of EOTC's policy of using some LRV's on this service.

The proposed project would provide exclusive lanes for streetcars between Brigham Circle and Heath St. It would utilize a new reservation between Brigham Circle and the Huntington-South Huntington intersection, and private right-of-way behind existing buildings, or on reservation, or a combination of the two (one track on each) between Huntington-South Huntington and Heath St. Alternatives for rail or bus service beyond Heath St., on the present alignment, or along Heath St. must be considered. Buses may share the streetcar right-of-way if justified, and adequate provision for transferring between connecting routes is required. Vehicular traffic capacity and safety must be improved as well.

V.A.3. North Station Green Line Relocation

This project involves the replacement of the existing elevated Green Line structure on Causeway Street with either a new elevated structure north of Boston Garden or a new tunnel under Boston Garden. Both alignments reconnect with the existing Green Line viaduct over the Charles River.

The new elevated structure would follow an alignment between Boston Garden and the Analex Building - either through Accalon Way or through a narrow (approx. 30' wide) parcel now occupied by a 3 story appendage to the Boston Garden. Both alignments have engineering constraints and require additional study. The elevated structure would cross over the extended B&M commuter rail tracks and a new station would provide multi-escalator access to the platforms below. The structure would then parallel the Fitzgerald Expressway and reconnect with the existing elevated Green Line structure at Lomasney Way.

The new tunnel would follow the narrow alignment between the Boston Garden and the Analex Building parallel to the new Orange Line Tunnel. It would then pass under the extended B&M commuter rail tracks (a new station would provide multi-escalator access to the platforms above) and follow one of two possible alignments to the Green Line Charles River Viaduct: (1) under the Fitzgerald Expressway and parallel to Nashua Street on the north side - the portal would be located in an existing parking lot, (2) under Nashua Street and parallel to the Fitzgerald Expressway Ramp - the portal would be located in an existing parking lot west of Nashua Street, the tunnel alignment parallel to the existing Orange Line Tunnel has serious engineering problems and requires detailed analysis.

An alternative alignment would be a deep bore tunnel under the Boston Garden.

Costs. The approximate cost estimate for the new elevated Green Line structure is $18,000,000. The approximate cost of the new tunnel is $58,000,000. Right-of-way, property acquisition and land damage costs are not included in this estimate. Planning for this option has now been incorporated into the MDPW/CTPS Central Artery feasibility study.

V.A.4. Extension of Green Line to Somerville

The 1966 Program for Mass Transportation included a short extension of the Green line from Lechmere to Washington Street Somerville, near Union Square. At that time the Red Line extension was not planned to serve Somerville, and the Green line extension was considered the only manner of providing service to that transit oriented city. In March of 1976, the Authority held public hearings and fixed on application with UMTA for a $300,000,000 Red line project for the Northwest corridor, including a stop at Davis Square.

The addition of the new Red line alignment makes a major impact on the potential ridership of a Green line extension. Because of its exceedingly slow running times to Park Street, the Green line extension would draw only a negligible number of riders from the feeder bus network. Those riders already on board a feeder bus would transfer either at Sullivan station or at Davis Square for the majority of bus routes in the area. The present ridership forecast for a Ball Square/Tufts extension is 7,000 riders per day,(primarily walk-in riders.) This forecast is being recalculated now for refinement in the final PMT. Capital costs in 1975 dollars are currently estimated at $44,million.

a. Lechmere to Washington Street the proposal calls for relocating Lechmere Station on the opposite side of the McGrath Highway on an elevated structure which patrons could reach by an elevated passageway over the highway. Bus access would be at grade. The Green Line would be extended northward from new Lechmere Station, remaining on viaduct to facilitate continued rail freight access to the industrial properties adjacent to the right of way. Near the B&M's New Hampshire Division, the Green Line extension would gradually descend and join the New Hampshire Division to use two tracks for its alignment to Washington Street, Somerville - its second station location.

Costs.The approximate cost estimate for this project is $19,135,(not including any property acquisition and right-of-way costs. This estimate is based on updating the 1967 cost estimate by Gibbs and Hill Inc. (Massachusetts Bay Transportation Authority: Central Area System Study, Phase I Report, July, 1967).

b. Washington Street to Ball Square using two of the four tracks in the New Hampshire Division right of way, the Green Line could be extended to Ball Square (the Broadway crossing of the tracks) taking advantage of the fully grade-separated alignment to accomplish its route. Stations would be located at McGrath Highway, School Street, Lowell Street and Broadway. All station locations are within the City of Somerville and would be provided with connections with bus routes servicing Somerville, Medford and Arlington.

Costs the approximate cost estimate for this leg of extension is $19,100,000, excluding right of way and property acquisition costs.

c. Ball Square to Tufts an appropriate further extension from Ball Square would be a connection to Tufts University. This extension would continue in the B&M New Hampshire right-of-way of four tracks, using two tracks for transit and two for rail service. An additional station would be provided at the terminal adjacent to the Tufts campus.

Costs the approximate cost estimate for the further extension (Ball Square to Tufts University) is $5,800,000, not including right-of-way and property acquisition costs.

V.A.5. A Possible Lechmere Area Green Line Storage Facility

a. Existing Conditions At present overnight car storage facilities on the Green Line are located at Boston College, Cleveland Circle-Reservoir, Riverside and Arborway, all of which are on the western ends of the routes they serve. At various locations on the intown end of the system there are limited capacity sidetracks used for storage of work equipment or disabled cars, but none of these is adequate to serve as a base for scheduled service. Under current schedules the first morning trips westbound from Lechmere start at Boston College and Cleveland Circle those from North Station at Reservoir, and those from Park St. and Government Center at Arborway.

b. Impact of Lack of East End Yard on Operations If the Green Line were serving primarily demand to downtown from points west, service from eastern termini could commence with arrivals of the first trains needed to serve trips from western termini. In fact the Green line serves heavy demand in both directions and

westbound service would not begin early enough if eastbound trains were dispatched only as required by eastbound demand. An analysis of ridership indicates that morning service from Boston College, Cleveland Circle-Reservoir, and Arborway now begins 45 minutes to 1 hour earlier than required to serve eastbound demand due to the need to provide trains for westbound service. Similarly operation of multiple-car trains from the west instead of single cars begins about 1 hour earlier than needed for eastbound demand. At the end of the westbound peak period 3-car trains continue to arrive at Lechmere, North Station, Government Center and Park St. for about 45 minutes, and due to lack of storage space are returned to their starting points with no reduction in length. Excess capacity provided in the evening peak is much less than that in the morning because the demand is better balanced.

c. Benefits of East End Storage Due to the fact that the number of cars flowing in each direction over any line must be equal over 24 hours in order to provide the same start-up conditions each day it is impossible to operate a schedule that provides only the amount of service needed in each direction unless demand happens to be perfectly balanced. An east end car storage facility for the Green line (probably located in the vicinity of Lechmere) would, however, allow a reduction in unnecessary capacity now provided. A preliminary analysis by E.O.T.C. staff assuming use of the new Light Rail Vehicles indicates that operating costs for the Green line with east end storage would be approximately $450,000 per year less than operations without east end storage.

The PMT planning process should examine closely the options for providing this additional yard capacity at the east end of the line. In terms of operating costs and service levels, the project could return a high level of benefit.

V.B. Major Downtown Distribution Improvements

V.B.1. Blue/Green Connection

The most heavily used stations on each of the three M.B.T.A. rapid transit routes and on the light rail Central Subway are all contained in an area less than one quarter mile square in the heart of the Boston Central Business District. Within this area the Orange line and the Central Subway (Green Line) each intersect both the Red line and the Blue line, and free transfer are permitted. The Orange line and the Green line connect at Haymarket Station, 1/4 mile north of their intersections with the Blue line and again at North Station. However there is no direct connection between the Blue Line and the Red Line. Passengers desiring to travel between stations on these two routes must make a double transfer via either the Orange line or the Green line.

The Blue-Green connection is one of two possible projects to improve interconnection at the Center of the network. The other project, the Blue-Red connection, is discussed below in Section V.B.2 of this Staff Report. This project would connect the tracks of the Blue and Green lines via a new downtown tunnel, allowing through-routing of vehicles between the two lines. Blue line passengers would be able to transfer directly to the Red line at a new station to be built west of the existing Park St. Station. The alternative project would be a subway extension of the Blue line from its present downtown terminus at Bowdoin Square to the Charles St. Station on the Red Line. Tracks of the two lines would not be physically connected, but a free transfer would be provided.

The existing Blue Line subway was originally built for and used by streetcars. For this reason curvature and clearance restrictions in the subway are similar to those of the Green line subway; and therefore allowable vehicle dimensions on the two lines are largely similar. Cars used on the Blue Line at present have high-platform loading, whereas Green line cars have low-platform loading. In order to through-route vehicles between the two lines it would be necessary either to have a common platform height or to acquire vehicles capable of either high or low level loading. The M.B.T.A. Central Area Systems Study, (CASS) completed in 1971, analyzed a Blue Line-Green Line connection under a variety of assumptions. In the final recommendation, the consultant proposed the use of a vehicle with "movable steps" to serve both high platform stations in the downtown area, and low platforms on the at-grade sections of the Green Line.

The CASS Study recommended future analysis of convertible high-low level platform cars for use either on the Green Line alone

or on a connected Green Line and Blue Line, but no detailed examination of convertible vehicles was included in the CASS reports. The new light rail vehicles (LRV's) now on order for the Green Line have the capability of conversion for both high and low level loading, but will be equipped only for low-level loading when delivered. (A fleet of L.R.V.'s for San Francisco being built simultaneously with the Boston order is being equipped for both high and low level loading). With use of corrective high-low platform L.R.V.'s a Blue Line-Green line connection could be made without the need for immediate conversion of all Central Subway stations to high platform. This would allow continued operation in the subway of vehicles equipped only for low-platform loading. At a later date with a full fleet of convertible cars selected platforms on all platforms in the Central Subway could be raised, but surface stations could be left with low platforms. A preliminary feasibility analysis of connected Blue and Green Lines operated with L.R.V.'s equipped for high and low level loading has been conducted by E.O.T.C. staff with the following findings:

a. Tunnel clearances and curvative in the Central Subway are slightly more restrictive than those in the Blue line subway, so vehicles designed for the Green line should be able to operate on the Blue line. There are a few exceptions to this in the Blue Line tunnel between State and Bowdoin stations. However, clearances could be widened at little capital cost. However the slight extra width of L.R.V.'s compared to present Blue Line cars, plus the door design of the L.R.V.'s would require removal of about 5 inches from the platform edges in Blue line stations. In addition, the lower clearances of the LRV were not designed to clear the third rail.

b. Present Blue Line car floor heights are 5 inches higher than L.R.V. car floor heights. Therefore some track raising would be needed in Blue Line stations to properly match L.R.V. platform heights with station platform heights.

c. The maximum capacity of the existing Blue line cars, allowing 2.5 sq. ft. per standee is 115 passengers. The capacity of an L.R.V. assuming the same loading standard is 160 passengers. Therefore to maintain line capacity 3 L.R.V.'s would have to be substituted for 4 Blue line cars. L.R.V.'s can be operated in 3-car units, but due to Green Line platform lengths in the subway it is planned to operate peak trains of 2 cars only. This will allow at least two trains to load simultaneously at most stations, as at present.

d. Operation of 3-car trains of L.R.V.'s on a connected Blue-Green Line is further constrained by the Blue line itself. The length of 3 L.R.V.'s is about 21 feet greater than the length of 4 Blue Line cars, and platforms at some Blue Line tunnel

stations are barely long enough for 4-car trains of present equipment. In one option, the stations could be lengthened. Alternatively, it would be possible to stop a 3-car L.R.V. train with all working doors inside existing stations, but the front and rear of the train would have to extend into the tunnel. This might interfere with proper visibility of doors for the first car operator. The end of car doors on L.R.V.'s would be usable only for low platforms in any event due to the tapered car side.

e. The L.R.V.'s are designed for overhead power collection, but the Blue line has overhead power distribution only between Maverick and Wonderland. Between Maverick and Bowdoin the Blue line has third rail power. In order to operate L.R.V.'s on this segment it would be necessary either to equip the L.R.V.'s with third rail or to install overhead wire. There is sufficient clearance in the tunnel for installation of overhead wire, but the lower maintenance cost of third rail makes it preferable on high-platform lines.

Both the CASS study and the E.O.T.C. analysis concluded that the operating costs of connected Blue and Green lines would be significantly more expensive than operation of the two routes individually. A major reason for this result in both analyses was that the different peaking characteristics of the two routes required over-serving of one line in order to serve the demand on the other during most hours of the day.

V.B.2. Bowdoin-Charles Connection

a. Physical Description. This project would extend the Blue line subway from its present terminus at Bowdoin Square under Cambridge St. to Charles St. station on the Red line. Tracks of the two lines would not be connected, but passengers would be able to transfer directly from one line to the other instead of using the Orange or Green line as a connecting link. Connection of the Blue and Red line tracks is infeasible for several reasons. Due to the restricted clearances of the existing Blue line tunnel, Blue line cars are 11 inches narrower than Red line cars at platform level. With the normal clearance at Red line platform, there would be a gap of 8.5 inches between platform edges and the sides of Blue line cars, which would be dangerous for boarding passengers. In addition floor heights of Blue line cars are 8 inches lower than floor heights of Red line cars. The existing Charles St. station is located on a short elevated structure adjacent to the Charles River. Any physical connection at that point would cause severe environmental disruption.

The extension has been proposed because it was thought to be a fairly inexpensive method to eliminate one of the two transfers necessary to move between the Red Line and the Blue Line. This would save time for those users, and would free some of the congestion encountered at Park Street station and on the Green Line, used to make one of the transfers.

The CTPS design section estimates a construction cost of $39.9 million for the extension, including approximately $10 million for water and underpinning problems at Charles station.

b. Method. The time savings each passenger would realize from this connection were calculated. Vehicle travel times on the existing system, platform-to-platform walk times, and estimated average wait times (= ½ H) from scheduled headways, were established. The estimated travel time between Bowdoin and Charles assumed a vehicle acceleration and deceleration of 3 fps^2 and operating speed of 72 fps. Transfer time at Charles was assumed to be 1.0 minute via escalator. Outdoor walking times, where appropriate, were estimated at 250 feet per minute. Link times include station dwell times.

1980 demand on the new link was calculated. All transit trips made between selected pairs of zones would use the new link. In effect, this was an all-or-nothing path assignment for which the Bowdoin-Charles link is thought to be on the 1980 minimum-time path. Next, it was necessary to estimate the number of new riders attracte to the system as a result of the improvement in travel time, and to expand the trip table to 24 hours. Induced travel was calculated by estimating present received travel time (with waiting time weighted by a factor of 2.5) and the change in perceived travel time. Using an elasticity of -.55, the increase in trips

for relevant zone interchanges was calculated.

To estimate user time savings, actual time savings were used for each interchange (separated into five groups), and multiplied by the number of trips. This was done separately for peak and off-peak trips. The 24-hour time saving was expanded to an annual time saving by using an expansion factor of 300(since travel on weekends is less than on the base weekday).

c. Ridership. This demand analysis shows that this new link can be expected to carry 5500 passengers each way each weekday. This compares to a peak line volume of approximately 45,000 on the Red Line and 65,000 on the Green Line, one-way. Of these 5500 users, 500 are new riders on the rapid transit system, attracted by improved trip times.

d. Benefit. The annual time savings are estimated at 225,000 (actual) passenger-hours. If valued at $3.00 per hour this is worth $675,000 per year. Ignoring, for the moment, increased operating costs, this can be capitalized (using a .07 capitalization factor) to yield a one-shot value of $9.64 million. Conversely, this may be viewed as a 1.7% return on the estimated $40 million investment.

e. System Impacts. Some of the present transit users who are expected to use the Bowdoin-Charles connector would otherwise make a transfer at Park Street. Others might exit at Park Street or another station and walk to their destination, and still others might make the transfer elsewhere. Those making a trip through (rather than to) the downtown area would most likely have previously made a transfer at Park Street. The 1980B trip table shows 1317 peak period trips in this category, or (using a 1.7 24-to-peak ratio) 2239 24-hour trips each way. Allowing for some diversion of downtown-destined trips, approximately 2500 daily transfers each way are eliminated at Park Street.

Data on transfer movements at rapid transit stations is not collected regularly. Central Area System Study, projected 1975 transfers with their downtown transit assignment model, and these "1975 H" figures are comparible to CTPS 1980 figures.

Congestion in Green Line vehicles between Park Street and Government Center will be reduced. The 25158 daily riders from Park to Gov't Ctr will be reduced by 2500, or about 10%. Dwell time will also be reduced, though only slightly. From the CASS figures, we can see that on Eastbound Green Line trains at Park Street, we have approximately 40,000 alightments (allowing 2000 eastbound boardings which entered at Park Street from the street), 16,000 through, and 9300 boardings. A reduction in boardings of 2500 (from eliminating transfer) will reduce on-off movements by 5%. This amounts to about 4 seconds per train (observed dwell time = 1 min, 20 sec.), affecting 25,000 riders each way, for 55 passenger-hours saved each day, or 16,500 passenger-hours a year.

Dwell time savings on Red Line trains are insignificant, due to more efficient loading and unloading of high platform cars with 6 or 8 wide doors.

While these figures are not precise, it can be seen that the Bowdoin-Charles connector will have a perceptible, but not major, effect on congestion and dwell times at Park Street.

V.B.3. Stuart - Huntington Tunnel

The possible tunnel under Stuart Street was conceived to assist in the alleviation of congestion of the most heavily used section of the subway system - the Green Line between Park and Copley Stations. It accomplishes this objective by providing additional capacity for Green Line vehicles in a heavily travelled corridor, and by eliminating the troublesome at-grade Copley Junction between the principal Green Lines to the west and the Arborway-Huntington Green Line into the Fenway.

The proposed tunnel would connect into the existing Green Line tunnel via the unused flying junction at Boylston Station (see Fig-11). It would extend under Tremont Street to the intersection of Stuart Street and extend the full length of Stuart Street through the Back Bay business are to an intersection with the existing Huntington Avenue tunnel. The length of the proposed tunnel is 4700 feet, including its extension under the Mass. Turnpike just prior to its intersection with the Huntington Avenue Line, Two new stations would be provided - one in the Park Square vicinity and other in the Copley Square area.

The approximate cost for this project is estimated at $56,300,000, which is based on updating the 1958 estimate by DeLeuw, Cather & Co. ("Report Regarding the Proposed Stuart Street Subway and Extension and Alteration to Existing Subways", December - 1958). In the cost updating provision are also made for a deep bore tunnel under the Mass. Turnpike which has not in existance in 1958, and the DeLeuw Cather estimate had assumed cut and cover method. No allowance for property acquisition on land damage is made in this estimate.

Ridership for this project has not yet been calculated for PMT purposes for this project. Considerable further analysis is needed before this project can be considered for advancement. Ridership and operational considerations are now being analyzed as part of the PMT planning process.

V.B.4. Long Term Reconstruction of the Central Subway

One major long term planning option for improving both capacity and service level through the "spine" of activity that stretches from North Station to the Back Bay is to reconstruct the existing Central Subway (Green Line tunnel) to high platform standards. Such a project would be a major alternative to the Stuart Street Tunnel, and other proposals to increase the capacity and service levels of the downtown system.

Eventual conversion of the facility has been considered for several decades, and incorporated into several design changes brought about to date. For example, the Government Center Station was reconstructed in the early sixties to allow for a two track tangent (straight) section to exist on the Northbound track section of the facility. The columns are placed so as to allow a small distance of track relocation necessary. In the early seventies, Haymarket Green Station was moved several hundred feet to a perfectly straight section of track, abandoning the original location on a series of difficult curves.

This analysis stresses the concept of Central Subway construction as a Long Term option. The decision concerning the efficiency of such an operation cannot be made with accurate data at this point, but that data will become available over the next two years. Specifically, it is impossible to predict at this point the precise results of the Authority's continuing Green Line improvement program. In two years, the Central Subway will have new roadbed, new track, modified signals, and a new fleet of low platform equipment.

Many of the Green Line's distribution problems at present are attributable to unmanageable dwell times caused at stations which require PCC boardings on the left where there is only one door, making worse the problems inherent in low platform loadings in high volume conditions. It is not possible at this point to predict the dwell time characteristics of the low platform LRV's with any certainty. As noted above in Section IV B.1., the LRV's being constructed for the San Francisco "MUNI" operation will be operated in downtown tunnels as high platform vehicles. Because of this fact, Boston has an excellent opportunity to allow San Francisco to do the experimenting with this potentially valuable mode of operation. Light rail vehicles with high/low platform capability are in common operation in Germany today, arguing against the idea that this represents another "untried technology".

The San Francisco experience in the Market Street tunnel will offer a perfect "laboratory" test with which to compare the downtown distribution capability of the otherwise identical vehicles. The need for a direct comparison is based on the fact that the vehicles will have 3 doors per side when in the low

platform mode, versus only 2 doors per side in the high platform mode. This is because the front door, designed for fare collection, is tapered away from the high platform and thus unusable.

This PMT analysis does not support the concept that the LRV's should be equipped with the high/low capability in the near term. Specifically, the Authority does not want to take any action that would make the vehicles more mechanically complex at this time. Pragmatically, it would not be wise to take any step which would cause the delivery schedule to slip further.

In the long term, however, after a period of precise examination of the comparative performance of the San Francisco and Boston downtown distribution tunnels, the option of some level of Central Subway reconstruction could provide an exceptionally high level return. In the Central Area Systems Study, careful analysis of an alternative which connected the Blue and Green Lines, and then converted part of the Central Subway to high platform, showed that the vast majority of user benefit stemmed from the improved travel times from the west to Park Street, and not from the Blue-Green connection.

Any travel time savings between Copley and Park Street will have high levels of user benefit, based on the magnitude of the volumes affected. This section, between Copley and Park, has the highest 24 hour traffic volumes in the entire system, and a technology not entirely well suited to high volume characteristics. With up to 120,000 trip makers per day, a time savings of 2 minutes will result in more than $3.6 in annual user benefit, which is exceptionally high.

There are many possible configurations for a long term reconstruction of the Green Line to high platform operations. In the past, consideration has been given to by-passing Boylston Street Station, and to retaining it. Ultimate connection with the Blue Line remains a possibility, although probably less effective an investment than originally expected. Lower levels of the general project could involve change as small as raising all station platforms 8 to 10 inches to meet the lowest level step of a permanent low platform operation.

V .C. The Transit Circumferential Project

V .C.1. Background

The Program for Mass Transportation will include initial recommendations as to the timing of implementation of the proposed improvements to circumferential transit travel in the core area. The Circumferential project was a major policy recommendation of the BTPR, and has been included in the latest TDP/TIP as a construction project for the 1980's. At the present time the CTPS is about to undertake a major revision of the BTPR study with an emphasis on a program of phased incremental implementation of this major project. A major emphasis will be placed on the definition of early spin-off projects which can be advanced before resolution of legitimatecy core-wide issues. This section of the Staff Report reviews major planning information created to date. The major conclusions noted here, however, are the subject to revision and re-examination in the comprehensive CTPS study now being undertaken.

Concept of Transit Circumferential. As shown in Figure the Transit Circumferential is intended to serve the "Fringe of Core" area--the area contiguous to downtown Boston which serves functionally as an extension of the Core, with a heavy concentration of major regional commercial, institutional and educational facilities. The heavy level of travel demand for the activities already in the area, plus the potential for expanded Core development intc this ring, argue for extension of Core-level transit accessibility to this area.

This attitude is based on a concept for the development of metropolitan Boston which envisages the expansion of core intensity functions beyond the traditional center of the Government Center-Financial District-Retail Core-Back Bay area. This expanded core includes Charlestown, the B&M yards area of East Somerville, Kendall Square-MIT, the Kenmore-Fenway and Dudley Square areas, the South End, and the Fort Point Channel region of South Boston. This is an area that was to be served by the Inner Belt highway, the rejection of which leaves a gap in the regional travel service pattern and a heavy unmet travel demand--a need which the Transit Circumferential could in part fulfill.

The expanded core is an area both of potential extension of core commercial activity, and of already regionally dominant institutional activity. The core commercial functions have in the recent past begun to penetrate the area, as evidenced

in the office complexes constructed around Kendall Square; and there is the near-future prospect of more such intense development in the Kendall-Lechmere area, South Boston, and the B&M yards. Bringing high-grade service to the institutional concentrations in this area recognizes the importance of this activity as a basic factor in Boston's national significance and a primary element in the regional economy. The circumferential ring is dominated by a great density of major institutions (See Figure 12) including MIT, Boston University, Harvard Medical School and its associated hospitals, Simmons College, Boston State College, the Museum of Fine Arts, Northeastern University, Wentworth Institute, Boston City Hospital, and B.U. Medical Center, to mention only the very largest--that have witnessed a great intensification of activity within the last decade. These major trip-generators represent a vast unmet demand area for public transportation.

In conjunction with the concept of providing service to the expanded core, the Transit Circumferential is meant to provide an alternative movement pattern to the strictly radial system now in existence--a system that requires arduous "radial-in and transfer to radial-out" trips to gain access to many destinations in this area. The new facility would offer accessibility via crosstown movement along the circumference of the expanded core, bypassing the intersection of radial lines at the old downtown center. This would also give relief to the over-congested stations and links of the central subway system.

The Transit Circumferential would intercept all the radial transit lines it crosses, permitting direct transfer between facilities. The primary function of the circumferential would be as a distributor from these radials to the intense demand areas of the fringe. Secondarily, it would serve line-haul circumferential corridor movements, and only incidentally a collector function in certain residential areas. The benefits the Transit Circumferential offers are as a functioning part of the overall transit network more than as a facility by itself--in the decongestion of the core and the distribution improvement for the radial lines.

V .C 2. Service Area Definition and Description

The service area for the Transit Circumferential on which analysis to this point has focused is that segment of a ring around downtown Boston running from a Red Line intersection at South Station, through the Dudley Square and Fenway-Kenmore areas, to a Red line intersection in Cambridge (See Figure 12). This corridor is the prime area of expanded

CIRCUMFERENTIAL TRANSIT CONCEPT PLAN

FIGURE 12

CORE AREA 0 1200 3600 6000 FEET

core activity, with its great concentration of major institutions and its recently developed extensions of core commercial functions. It is an area of heavy existing transit demand - with intense trip-generation among employees, students, patients and visitors - which is underserviced by the present transit system. And it is an area of great potential growth in transit usage, both from continuing institutional and commercial expansion, and from attraction and inducement by a high-quality transit service not before offered in any form. It is the corridor of the now-rejected Inner Belt highway, which was intended to meet a very heavy demand for circumferential and cross-town movement, part of which could be satisfied by a Transit Circumferential facility.

Within the corridor, the sector of heaviest transit service need is the Kenmore-Fenway area, from the Charles River to the Relocated Orange line. It is the area of the densest concentration of institutional population in metropolitan Boston--and thus a major resource to the region's prominence--including Boston University, Wheelock, Emmanuel and Simmons Colleges, Boston English and Boys Latin High Schools, the Gardner Museum and the Museum of Fine Arts, Harvard Medical School and its many associated hospitals, Massachusetts Mental Health Center, Boston State College, Wentworth Insitute and Northeastern University. It also covers the Kenmore Square retail area, the light industrial/warehousing activity in the vicinity of Fenway Park, and the residential neighborhoods of Longwood and Cottage Farm in Brookline, and the Fenway and Brigham Circle areas of Boston, including the Mission Hill housing projects.

This area is presently served by the four Green line radials, and soon by a Relocated Orange line radial--all of which a circumferential facility would intersect. But the generators in this area also have strong need for "crosstown" transit accessibility for residential origins and for interaction with other institution, from the Cambridge-Northwest area and from Roxbury-South Station and South. These movements are at present very difficult to make via transit. It is necessary to travel downtown on other radial lines and then reverse transfer out via the Green line. These travel patterns have been documented in Section III of this Staff Report.

To the east of the Relocated Orange line, the circumferential corridor encompasses the 5000-student Campus High School, already under construction, and the Dudley Square area, the major retail and community facility center for the Roxbury community. At Dudley it intersects the alignment of the proposed South End transit line running from downtown to Dudley Square. The "inner belt" alignment is the same as presently identified for the proposed Roxbury Replacement service, with

potentially combined service to the heavily transit-dependent, predominantly black population along this corridor. This area of the corridor includes the residential community of Lower Roxbury, with many old and new housing projects, and the major development potential in the cleared land of the Inner Belt corridor.

Northeast of Dudley the circumferential corridor covers a major light industrial/warehousing area continuing to the vicinity of South Station. This area also includes the large complexes of Boston City Hospital and Boston University Medical Center. These hospitals serve especially a lower-income, and therefore transit-dependent population; they also have strong functioning interactions with the previously-mentioned medical and educational facilities in the circumferential corridor, and thus a need for accessibility. The termination of this segment of the corridor at South Station provides intersection with and distribution from the Red Line South, the heaviest travelled radial, and the proposed South Station Transportation Center, the region's major train and bus terminal.

On the Cambridge side of the Charles River, several alternative corridor-alignments are being examined in the CTPS study. The foremost option follows the Grand Junction Railroad right-of-way from the B.U. Bridge to a Red Line intersection at Kendall Square. This serves an area which includes MIT, with its large student and employee population, and a vast commercial-light-industrial-research-and-development territory. This option readily permits extension through East Cambridge to the East Somerville-B&M yards area and completion of the loop to North and South Stations.

A second option is a corridor through Cambridgeport, a dense lower-to-middle income residential community with industrial areas on its eastern edge, to Central Square. This alignment would permit extension via Inman Square, Cambridge, and Union Square, Somerville, to East Somerville and beyond. However, for an alignment to Central Square, and beyond, there is no readily available right-of-way comparable to the Grand Junction Railroad.

The third option is a corridor through the Cambridgeport and Riverside communities, past a small industrial area and several development sites along the Charles River, to Harvard Square. This alternative stretches the circumferential out of the true expanded core area, partly duplicating the radial service provided by the Red Line, and would be very difficult to extend into a completion of the circumferential loop. As in the Central Square alternative, there is no readily available right-of-way comparable to the Grand Junction Railroad.

Several other corridors for a circumferential facility are being briefly investigated. These include: 1. Completion of the circumferential loop from Cambridge through East Somerville, Charlestown and North Station to South Station. The important North to South Station connection is being considered as part of the general downtown distribution and Central Artery question; and service to the East Somerville B&M yards area should be co-ordinated with potential development of the site. 2. Service to the South Boston Industrial Development Area and Logan Airport. 3. Connection to Columbia Point and U.Mass-Boston, where the University is currently operating its own Transit service, and site of the Kennedy Library and proposed State Archives building.

Within the primary corridor considered, from South Station to Kendall Square, there is a total population among the major generators of over 80,000 students and 75,000 jobs. In addition, there are more than 2,900,000 patients-visits and 1,100,000 museum visits per year. The large number of students, lower income employees and lower income residents to be served are particularly transit-dependent and in need of improved facilities. The potential demand for a circumferential transit facility in this corridor is approximately 30,000 riders per day in each direction.

V .C.3. Potential Ridership Demand Categories

The potential demand for a circumferential transit facility falls into four movements patterns:

a. Circumferential as distributor from radial transit facilities to destinations within the corridor. This includes the bulk of the home-to-work trips in the corridor, and general institutional, commercial and residential access. This is by far the largest service demand for a circumferential transit facility.

b. Movement from one radial, via circumferential, to another radial line--a very minor demand.

c. Circumferential Corridor Line Haul--from origin to destination both within the corridor. This includes some home-to-work trips, and inter-institutional and inter-commercial movement. The inter-institutional travel particularly should increase considerably in the future, and should be prone to inducement by the initiation of a service facility, in accordance with the expected growth in institutional facility-sharing and joint programs.

d. Local Movements, internal to the various institutional and commercial complexes in the corridor. The ability to offer such essentially pedestrian-aid service depends on the type and scale of transit facility implemented.

V .C.4. Transit Alternatives being Considered

The range of alternatives being considered in the PMT analysis for the circumferential transit facility cover a broad spectrum of technological modes--including bus, light rail, rapid transit and possible future technologies. Within these there is considerable variety in level of service, horizontal and vertical alignment, and service pattern.

a. Bus - The alternative being considered in the PMT analysis for bus service in the circumferential corridor include two major sub-options:

- Bus routes on existing streets mixed with general-purpose traffic.

- Exclusive bus right-of-way, utilizing possible new arterial construction for several segments of the corridor.

b. Light Rail - Two types of light rail alternatives are being considered in the PMT analysis.

- Primarily in exclusive surface reservation in the median of major arterials, with certain segments and intersections grade-separated.

- Primarily subway and depressed alignment.

The light rail alignments have been the subject of considerable PMT planning to this point. The cost data presented below assumes Green line technology as a first step in the comprehensive study.

c. Rapid Transit - Full rapid transit alternatives, primarily in subway, with parts depressed or in existing rail rights-of-way, will be considered both for independent circumferential and circumferential radial alignments.

d. Advanced Technologies - The CTPS study now beginning will examine all major technological option for providing improved circumferential. The study is designed to recommend a staged program of incremental improvements to the present core network. One possible mid-to-long term recommendation could involve advanced transit technologies not currently

proven in major service. Most likely the study would recommend near and mid-term investments which are technologically compatible with longer term adaptation to advanced technology modes.

The BTPR was optimistic that "Personal Rapid Transit" technologies would develop in the first few years of the seventies, and thus gave considerable attention to that particular technology. It is clear that a multi-origin, multi-destination technology could logically serve the circumferential study area. However, at the present time the transit industry is experiencing considerable difficulty in conversion to totally automatic train control hardward systems. In addition, the problems of automated vehicles in terms of potential for crime has not been solved to this point. Thus, it is clear that automated, un-manned transit technologies are not a near-term solution to the transit needs of this area. Further planning will concentrate on near and mid-term increments that do not freeze out latter options of improved technological implementation.

V .C.5. Design Constraints

The following are some of the major physical and environmental constraints on the design of transit facilities in the circumferential corridor.

a. Intersections with Transit Radials. Travel demand indications that circumferential distribution from radials is the prime function requires direct transfer with radials, wherever possible.

b. Kendall Square - Joint design required with Cambridge Redevelopment Authority redevelopment proposal, including MBTA rapid transit station and bus terminal relocation.

c. Grand Junction Railroad right-of-way - Integrated design required with proposed Cambridge truck route. Joint development possibilities with MIT.

d. Cambridgeport and Riverside Neighborhoods, Cambridge - Dense residential neighborhoods with no major through arterials to offer ready alignments.

e. Charles River Crossing - Environmental impact problems of elevated crossing on River and embankment parks. Possible integration with existing B.U. Bridge-RR bridge corridor. River and major parallel sewers are impediments to tunneling.

f. Cottage Farm and Longwood Neighborhoods, Brookline - Dense, affluent neighborhoods. Residents well-organized and sensitive to aesthetic-environmental intrusion.

g. Fenway-Parkland is registered National Historic Landmard. Extremely difficult environmental and 4(f) situation for any intrusion on park area.

h. Fenway Group Institutions and Harvard Medical Area - Large concentrations of regionally important institutions. Heavy demand area, but difficult to traverse densely-built campuses and complexes; aesthetic impact problems.

i. Inner Belt right-of-way - Integrated design has been assumed with proposed roadway alternatives. Joint development potential in cleared land.

j. Dudley Square - For direct service to important retail center and transfer to Washington Street transit line, dense commercial district with narrow winding streets must be traversed. Phasing relationship to removal and replacement of Washington St. Elevated must be considered.

k. South Station Transportation Terminal - Joint design required for integration with BRA redevelopment plan for proposed rail-bus-automobile terminal.

V C.6. Preliminary Alignment Decisions

The CTPS study will undertake a comprehensive Alternatives Analysis of the major options for circumferential service. However, for the PMT purposes it has been essential certain rough capital cost estimates for a logical circumferential project. Capital costs are presented below in Section VI.A.7 for one such possible Green line option.

This section is concerned with the analysis that led to a decision to concentrate on a Grand Let alignment in Cambridge, with service from BU, through the Fenway area on the Boston segment.

a. Rejection of BU-Harvard Square Alignment. North of BU and the Charles River, the proposed transit facility could be routed either in a radial configuration to Harvard Square, or completing the circumferential concept through Inner Cambridge, and on to an Orange line interchange to the north. Travellers who are on board the inbound Red Line trains as they approach Harvard station would not benefit from

a Harvard-SW circumferential alignment as compared with a Central Square transfer point. Southwest riders who either walk or bus into Harvard station itself, will have an extra mode and an extra transfer. Assuming a 24-hour weighted average headway of 5 minutes, the perceived travel time added to each trip for these riders is approximately 6 minutes (½ headway x 2.5). The primary benefit of a Harvard alignment would go to bus and walk-ins at Harvard Square.

The magnitude of inconvenience caused by not constructing a BU-Harvard linkage can be approximated by noting that the first year transportation benefit of 1,100 riders saving 12 minutes is approximately $165,000.

Because there are no pedestrian activity centers along this alignment a midway station at River St. could be expected to attract about 1,000 riders, and few of these would have destinations in the SW circumferential study area. On the other hand, the number of riders who would directly benefit from an alignment through Inner Cambridge to the Red line ranges between 5,000 to Kendall only and 10,000 if extended to Sullivan via Union. Thus, initial costing attention has concentrated on alignments through Inner Cambridge, rather than to Harvard Sq.

b. Orange Interchange at Sullivan vs. Community College. Like the basic decision between BU-Harvard and BU-Inner Cambridge alignment, a preliminary resolution of the Orange Line/circumferential station location appears justifiable on the basis of presently available data. There are two logical alternatives: Community College (at Prison Point Bridge) and Sullivan Station. The Community College Station is most logically approached through the Cambridge Parkway development, First Street, and southerly Lechmere Square area. An alignment approaching Sullivan Square would traverse the Union Square/Washington Street area of Somerville, and serve Sullivan Station, the terminus of most Somerville bus routes.

c.

Determination of the optimal Orange line connection must be based on 1) transfer volumes from the Orange line north, 2) transfer volumes from the Orange line south, and 3) bus and pedestrian feeder patterns of the two stations. Whether viewed in terms of Orange line connections, or bus line connections, Sullivan appears to be the most effective location.

When viewed in terms of Orange line transfers, a Sullivan circumferential station saves one minute of travel time for Orange line riders from north: Community College saves one minute of travel time for Orange line riders from the south.

The critical fact is that about 1,700 circumferential riders approach the facility from the Orange line north, and only about 1,000 from the south. The difference between volumes by direction is not overwhelming, but tends to mitigate in favor of a Sullivan Station.

In addition, Sullivan is much more important as a feeder bus terminal than Community College. Approximately 1,200 circumferential riders board from feeder buses and walk-ins combined. (Walk-ins, however, are not a major component of Sullivan boarders.) Thus, both in terms of relationship to the radial rapid transit and the extensive feeder bus network of Somerville, Sullivan appears to be superior to Community College as the northern terminus for further study in the CTPS circumferential project.

c. Routing Between Cambridgeport and Union Square. There are two basic alignments for the circumferential facility between the Charles River and Inner Somerville. This alignment choice is the most difficult in the northwest, and most susceptible to further analysis in the CTPS study. Both alignments would have a station in the Cambridgeport/ MIT west area. From there, one alignment would follow a general Prospect Street alignment, with stops at Central, Inman, and Union Squares. The alternative service for Inner Cambridge could have stations at MIT/Mass., Kendall and Union Square, with optional stations at Donnely Field on Cambridge Street, along the Grand Jct. right-of-way.

In terms of sheer volume, those desiring circumferential distribution from inbound Red line trains comprise the most important element of demand. Of the circumferential distribution demand by inbound Red line riders, about 80 percent is towards the south and west. From the criterion of effective Red line interconnection, an alignment including Central Square is superior to one relying solely on Kendall Square. Two prime functions are being supplied by the Cambridge alignment of the Circumferential Distributor. One, it is picking up Red line riders for distribution throughout the Southwest circumferential study area. Two, it serves to distribute riders to areas of developing land intensity, whose origins are predominantly south of Charles River. The effectiveness of the transit facility as a distributor of trip ends must be examined as carefully as its effectiveness as an interceptor of radial movements.

Using Walking distances of approximately 1/3 of a mile, the Grand Junction alignment serves a landmass with 15,200 transit trip ends, while the Prospect Street alignments serves an area with 11,600 transit trips ends. The Grand Junction alignment calculation assumes that only one station is constructed in the Kendall-through-Tech-Square redevelopment area.

It is worthwhile to examine the walk-in potential for Central Station, vs. that of MIT/Mass. plus Kendall Station. Central and Kendall are forecast to be similar in serving trips which walk to their destination (or from their origin). Thus, a sketch-planning summary of the direct (walking) distribution coverage of the two alignments finds Cambridgeport Station constant, Central and Kendall roughly equal. The differences between the two alignments can be reasonably understood to be the walk-in patronage of the MIT/Mass. Station, or about 3,000 daily riders.

In summary, the Kendall alignment ranks higher when judged in terms of effectiveness of transit trip end coverage. The Central alignment presents a more direct path for Red line to circumferential users as a whole and has a considerably larger role as a terminal point in the local feeder bus system.

This analysis is not concerned with comparative capital cost. The central observation being made here is that the user benefits resulting from bringing new accessibility to an underserved area far outweighs the benefit to be derived to a well-served node by significant service improvement. The fact that the Kendall/Grand Junction alignment is far less expensive than the Central/Prospect Street tunnel further supports the conclusions implied by demand data alone.

Viewed from the perspective a circumferential service going beyond the Red line to Sullivan, the Prospect tunnel looks somewhat stronger than in the Red line terminal perspective. If the direct comparison is made, Inman Square is revealed to be a stronger pedestrian activity generator than the Donnelly Field area served in the Grand Junction alternative, but still inferior to the Grand Junction route. However, even with this relative improvement in coverage, the Grand Junction alignment between Cambridgeport and Union Square covers an area with 20 percent more transit trip-ends than does the Prospect tunnel and at much lower cost.

d. South of the Charles River. The CTPS study will examine alternative alignments south of the Charles River. Initial attention will be paged to two alternatives. In the first, the circumferential facility stops at Commonwealth Ave. and the vehicles are through routed to the Commonwealth line. In the second, the tunnel continues towards the Fenway area.

The data presented earlier in this Staff Report shows that the Fenway Hospitals area has considerable need for circumferential connections, with about 5,000 non-radial trips initially isolated in the analysis. The capital costs presented below include two alignment options for the Fenway area.

VC.7. Initial Capital Cost Estimates

The CTPS analysis to this date has focussed on the Green line as the most promising near term technology option. If the Green line is extended northward from Lechmere in Cambridge, a connection to the Grand Junction alignment could be effected at the south approach to the Lechmere Extension bridge over the Grand Junction tracks. By this connection, the full right-of-way of the Grand Junction through Cambridge would become accessible to Green line vehicles. Maintenence of a Grand Junction rail freight line through Cambridge is essential, because it is the primary connection between Penn Central and B&M lines within the metropolitan area. Grand Junction rail freight service mandates the retention of the present gradient through Cambridge,with six grade crossings of local streets. With limited use of rail freight trackage, and with Green line service on two new tracks, the grade crossing problem may not be severe, except at high-volume locations.

Grand Junction Green line service would provide for interconnections between the Green line Lechmere Extension, the Red line at Kendall Square, the Orange line at Sullivan Square, and the Back Bay Green line in the vicinity of Boston University. Relatively light construction north of the river is required, except in the B&M rail yards, where short tunnel sections may be required for access to Sullivan Square Orange line Station. Crossing the river may require reconstruction of the existing railroad bridge, unless joint rail freight-Green line use can be effected. New bridges are required at Memorial and Storrow Drives. South of the river a tunnel, 600 feet long, would carry the Green line beneath the B.U. Bridge approach and Commonwealth Avenue to a new station for the B.U. community. A longer tunnel, under the Turnpike and Park Drive, is required for the Green line to reach the Beacon Street and Riverside Green lines. Through this tunnel extension a new major under ground station at Audubon Circle can provide for interconnections between the two Green line radials and points near B.U. and throughout the corridor in Cambridge.

A further extension of the Green line service could be constructed in the Fenway to provide a connection to the Huntington Ave. Green Line and the Relocated Orange line at Ruggles Street. This connection would be in tunnel for the

entire length between the Audubon Circle area and Huntington Avenue. Two new underground stations would be provided, one at Louis Pasteur Street and the other close to Wentworth Institute.

A second routing alternative receiving attention in on-going CTPS analysis is a variation which takes the facility somewhat west from Fenway Station to be routed under Longwood Avenue rather than under Park Drive. This alignment, while being about 25 million dollars more costly than the Park Drive alignment, serves directly the Fenway medical-institutional complex which the facility was designed to serve.

The approximate cost estimate for the fixed facilities, (excluding right-of-way, property acquisition and land damage costs) for the different options of this project, as shown in Figure 12, is summarized as follows:

I.	Grand Junction to Sullivan Square=	$ 38,800,000
II.	Lechmere to Memorial Drive=	23,300,000
III.	Memorial Drive to Boston University=	34,600,000
IV.	Boston University Park Drive=	51,500,000
V.	Park Drive to Huntington Ave., direct or via Longwood Ave., including Ruggles Station	102,600,000 (127,600,000)
	Totals via Park Drive	250,700,000
	via Longwood Avenue	275,700,000

V.C.8. Relationship with Roxbury Replacement

The reader is referred to Staff Report 5b concerning some of the options for Roxbury Replacement service. The full range of options include alignments across the "cleared land", with southerly extensions down Blue Hill Avenue or down the Midlands Branch. There are several alignment options unser consideration between the cleared land and either of the two possible radial alignments. Common to these proposals is some use of the cleared land parallel to the east-west arterial street from the area around Ruggles Street Station towards the intersection of Massachusetts Avenue and the Southwest Expressway.

To the context of fall circumferential service, the principle concern of this chapter is the feasibility and capital costs of extending the facility from Ruggles Street to Boston City Hall, and ultimately to the Red Line. It is unclear at this point how much of the potential circumferential alignment would be shared with the Roxbury Alignment. Therefore, full costs will be noted here with the understanding that certain sections of the alignment would serve to facilities.

If a Green Line technology were chosen for the circumferential, it is feasible to consider an at-grade alignment for the facility between Huntington/Ruggles station and Harrison Avenue, at which point some tunneling is necessary because of tighter right-of-way constrictions. The cost of such an alignment to Hampden Street, just short of Massachusetts Avenue, has been estimated at about $15 million, exculding engineering and contingencies. The same alignment with an open cut replacing the at-grad section, with cut and cover west of Columbus was estimated at about $48 million. Total cut and cover in the alignment is estimated to cost about $20 million more than the open cut option.

The cost of a vaiduct right-of-way from Hampden Street to the Southeast Expressway is estimated at about $15 million, excluding engineering and contingencies. Costs for the easterly connection with Red Line have not yet been calculated, as alignment possibilities have not been sufficiently narrowed; i.e. South Station, Broadway, Andrew, or University of Massachusetts.

V.C.9. Ridership for Circumferential

To this date there has been only one comprehensive study of ridership for a circumferential facility undertaken by the BTPR in 1972. Teh results of that study can be used to observe relative intensity of demand between sub-areas in the corridor. However, it should be noted that the BTPR study assumed an alignment that would be difficult to provide with rail technology. In the Boston University area, the alignment had stops at BU, Fenway and tied into Kenmore Station. In the hospitals area the alignment served Brigham Circle directly, in addition to stops at the Deaconness Hospital and Boston State. In short, the BRPR partial circumferential demand is enhanced by optimistic alignment assumptions.

A. Cambridge Alignment

Initial demand in this was found to be less than 3,000 riders per day, between Sullivan Station and Lechmere. However, between Lechmere and Kendall, 5,000 riders were forecast. In the MIT area, the annual Jct. alignment carried 9,000 riders. Traffic across the Charles was forcast at 6,000 riders in this study.

B. Boston Alignment

The line volume at Fenway Station, between the BU/Kenmore area and the Fenway Hospitals was the highest on the system, at 9,700 riders. However, demand held quite constant to the east, with 9,200 riders between Ruggles Street and the Dudley Square area. Between Boston City Hospital and the Red Line 7,700 riders were forecast for the BRPR facility. Additional demand through to South Station was lower at about 4,500 riders.

C. Total Ridership

The BTPR circumferential attracted between 60 and 70 thousand daily riders, with a nothern terminal at Kendall and

Sullivan respectively. This represents 30-35 people making two trips a day. This Staff Report notes that the forecast ridership will depend heavily on the travel time characteristics of the transit mode selected. These figures must be seen as upper range estimates for the technologies now under serious consideration in the CTPS study.

V.C.10. Distribution of User Benefit

It is the purpose of this section of the Staff Report to describe the way in which the benefits from intensive investment in distribution service are distributed throughout the subareas of the core study study area, and throughout the region itself. At this point in the CTPS study, there have been no detailed simulations of a circumferential facility of the type needed to compute the level of user benefit. As noted above, the BTPR examined an alignment and service level which is most probably better than that possible with light rail, bus, or rapid transit technology. Therefore, the absolute value of the user benefit found for the BTPR project (which was higher than any transit project except the Harvard-Alewife extension) is not of major concern at this point. However, the BTPR study was able to show the distribution of that benefit over various categories of transit trip-makers.

a. Examination of Benefit Distribution for Geographic Bias. Intensive investment in distribution services over a relatively small landmass must be seen in terms of its regional, network, implications rather than its immediate local impacts. Too narrow a geographic focus inevitably results in a misconception of the true function of the proposed facility in the total system of metropolitan transportation. Specifically, it is easy to interpret the Circumferential Project as a system with which to transport doctors from Boston City Hospital to Beth Israel, students from Boston University to M.I.T., or working people from the South End to Cambridgeport's industrial complex. Of course, the facility could do all this; but the handling of trips within the circumferential arc is by no means its principal transportation function, nor the manner in which it returns principal benefits to its users.

In order to illustrate the spreading of benefits over the geographical area, two critical questions are asked here: (1) Is the proposed circumferential facility primarily of benefit to the communities it directly serves? (2) is the proposed circumferential primarily of benefit to core area communities, or to the communities lying beyond the core area? The data quite clearly resolves the first issue, and serves to dismiss the preconception that the facility is primarily a link between institutions. Table 3 disaggregates the total annual user benefit derived from the Partial Circumferential into four categories:

TABLE 3

TRANSPORT BENEFIT BY TRIP CATEGORY:
THE PARTIAL CIRCUMFERENTIAL
(expressed in dollars of first year transport benefit)

Trips within Circ. Corridor	$2.6 million
Trips between Circ. Corridor and CBD	1.4 million
Trips between Circ. Corridor and Region	10.1 million
Trips external to Core	0.5 million
	$14.6 million (BTPR total)

Of the BTPR total of $14.6 million in user benefit from trips calculated in the computerized analysis, only $2.6 million derives from simple cross-town movements. The vast majority of benefit is created for users with regional connections. The conception of the circumferential as interconnector of universities is easily dispelled. However, a second serious question remains: does investment in distribution services (such as the circumferential) primarily benefit the residents of a relatively small segment of the region, failing to return benefit to the majority of communities who must inevitably share in the region's transit costs?

The transport benefits accrued from the Circumferential investment are not distributed disproportionately to the residents of the communities where the facility operates: benefits are distributed evenly over the transit-using region. This stems, of course, from the distinctly regional nature of the trip ends served by the Circumferential transit line: from their propensity to be destinations of home-based trips. (See Table 4).

TABLE 4

GEOGRAPHIC DISTRIBUTION OF BENEFIT
FROM PARTIAL CIRCUMFERENTIAL
(expressed in dollars of first year transport benefit)

Benefit generated by:

Trips Originating in Core	$9.4 million
Trips Originating in Rest of Region	5.2 million
	$14.6 million (BTPR total)

* * * * *

Benefit generated by:

Trips from Region to Core	$4.7 million
Trips from Core to Region	4.7 million
Trips within Core	4.7 million
Trips external to Core	0.5 million
	$14.6 million

* * * * *

Benefit to Core Area Residents:

13% of travel between core and region	$1.2 million
Travel within the Core Area	4.7 million
	$5.9 million

Benefit to Residents external to Core:

87% of travel between Core and Region	$8.2 million
Trips external to Core Area	0.5 million
	$8.7 million

TOTAL $14.6 million

VI. Possible Use of Commuter Rail for Core Area Stations

A. Inner Suburban Station Background: In the past all of the existing commuter rail lines in the Boston area had stations much closer to the Boston terminals than the nearest stations now served. These inner suburban stations were gradually phased out beginning about 1920 and ending about 1960. A number of factors were responsible for closing of these stations. In most cases patrons of these stations were also able to use combinations of streetcar and rapid transit service, or later buses and rapid transit. This alternate service, although offering slower running times provided more frequent departures and lower fares. The inner suburban stations were generally served by short-turn trains rather than by through trains. As operation of short turn trains became uneconomical some attempts were made to serve the inner stations by having trains from more distant points stop at them. This resulted in lengthening the running times on the through trains, which discouraged ridership from further points to some extent. If the through trains were already operating at capacity, serving inner stops required adding extra cars and crewmen. This was costly, as the extra equipment and personnel had to be carried through to and from wherever the outer ends of the runs were, but might be needed for ten miles or less from Boston. Thus, the decision of rail management often was to give up entirely on inner suburban business.

B. Reactivation of Inner Suburban Stations by MBTA: The MBTA has subsidized commuter rail service of the Boston and Maine Corporation since 1965 and service of the former New Haven Railroad (now ConRail) since 1966. In response to community requests the MBTA has reactivated five inner suburban stations that had been closed by the railroads several years earlier. These reactivations and the results thereof are described below.

a) Arlington Station This station on the B&M Lexington Branch was closed in 1958 and reactivated in 1965. One round trip per day (the only train running on the branch) stops at Arlington. Daily boardings at this station have ranged from 7 to 12. Although small, this ridership is equal to or greater than that at many of the stations further out on the line. Under the current fare structure a single ride from Arlington to Boston costs $1.10, with an additional 25 cents to transfer to rapid transit at North Station. A regular commuter from Arlington could reduce his fare per trip excluding connecting service to a minimum of 59 cents by purchasing monthly commutation tickets and riding the train both ways every week day. By comparison MBTA bus service from Arlington to Harvard plus rapid transit service downtown now costs a total of 50 cents. The scheduled run time from Arlington to North Station by train is currently 23 minutes. An additional 13 minutes is required to reach the intersection of Sunmer and Washington Streets, taken as a typical downtown destination, from North Station. By comparison the scheduled time from Arlington to Washington Station via bus to Harvard and transfer to the Red Line is 32 minutes.

b) Lake Street This station, also on the Lexington Branch in Arlington was closed in 1958 and reopened in 1968. Daily boardings at Lake Street have ranged up to 10. Fares are the same as those at Arlington described above. Although Lake Street is located further from MBTA bus routes than is Arlington Station all points within walking distance of Lake Street Station are also within walking distance of bus service.

c) Belmont Station and Waverly Station These two stations located on the B&M Fitchburg route were closed in 1958 and re-opened in 1973. Six weekday inbound trips are scheduled to stop at both stations, and 13 other inbound trains will stop on signal. Sixteen outbound trains will stop on request at either station. Approximately 35 daily riders board at the two station combined. Fares at both stations are the same as those at Arlington described above. Scheduled run times to North Station are 18 minutes from Waverly and 16 minutes from Belmont. An additional 13 minutes is required to reach the intersection of Summer and Washington Streets, taken as a typical downtown destination, from North Station. The scheduled travel time from Waverly to Washington Station via trackless trolley to Harvard and transfer to the Red Line is 31 minutes, the same as the combined commuter rail and Orange Line time. From Belmont Center to Washington Station via bus to Harvard and transfer to the Red Line the scheduled travel time is 33 minutes.

d) Forest Hills Station This station, located on the former New Haven Railroad Providence Main Line at its junction with the Needham Branch was closed in the 1940's and reopened in 1973. All service to the station is provided by Needham Branch trains. Four weekday inbound trains and five outbound trains make scheduled stops at Forest Hills. 8 additional trains in each direction make flag stops at Forest Hills. Approximately 50 inbound daily riders board commuter trains at Forest Hills. By comparison all but one other station on the Needham Branch attract over 100 daily riders each, and the MBTA rapid transit station at Forest Hills, located next to the railroad station, attracts 15,000 riders per day. Under the current fare structure a one-way railroad ticket from Forest Hills to South Station costs 80 cents. Buying a monthly ticket and using the rail service both ways every day reduces the one way fare to 63 cents. An additional 25 cents is required for a transfer to rapid transit downtown. By comparison the rapid transit fare to downtown from Forest Hills is only 25 cents. The scheduled commuter rail running time from Forest Hills to South Station is now 15 minutes. The running time via the Orange Line to Washington Station is approximately 17 minutes, but service is much more frequent on the Orange Line.

C. Possible additional station reactivations The MBTA commuter rail office and EOTC have received a number of suggestions for additional reactivations of abandoned inner suburban rail stations, or creation of new stations. Some of these proposed stations, like those discussed above, would serve mostly traffic to downtown Boston. Possible locations for these stations are in Chelsea, Everett, and Somerville among others.

Other suggested stations would serve as destinations for traffic from the outer suburbs as well as origins for intown traffic. Included in this category would be stations at Boston University, Northeastern University, and Tufts College. Preliminary analysis by EOTC staff of two potential inner suburban stations is described below.

a) Winter Hill Station, Somerville this proposal consists of reactivation of the Winter Hill station on the Boston and Maine New Hampshire Route near Somerville City Hall. This station was discontinued during the 1930's. With rehabilitation of track between Winter Hill and North Station planned under the Commuter Rail Improvement Program (CRIP) the run time from Winter Hill to North Station would be 4.5 minutes. An additional 13 minutes would be required to reach Washington Station, taken as a typical downtown Boston destination. Persons now going to downtown Boston from the vicinity of Winter Hill Station have a choice of four combinations of bus and rapid transit. Routes 80 and 88 connect with the Green Line at Lechmere. Routes 90 and 94 connect with the Orange Line at Sullivan Station. Routes 80 and 88 have headways averaging 8 minutes in the peak and 15 minute off peak. Route 90 has 30 minute peak and 45 minute off peak headways, Route 94 operates only during peak periods and has 30 minutes headways. From Somerville City Hall the scheduled travel time to Park Street Station via Route 88 and the Green Line is 26 minutes, or 8.5 minutes longer than the time from Winter Hill station to Washington Station via commuter rail and the Orange Line. From Medford and Putnam streets to Park street via Route 80 and the Green Line the scheduled travel time is 31 minutes or 9.5 minutes longer than the time to Washington Station via commuter rail. From Somerville City Hall to Washington Station via Route 90 and the Orange Line the scheduled travel time is 23.5 minutes or 6 minutes longer than the commuter rail line from Winter Hill.

Although the commuter rail travel time for a trip to downtown Boston starting at Winter Hill Station would be less than the time via existing transit service, the saving would be insufficient to outweigh the transfer time for those already on board buses passing the station, so demand attracted to the station would consist mainly of walk-ins and kiss-riders. If all trains now running on the New Hampshire Route were to stop at Winter Hill, the average headway during the peak period would be 17.5 minutes, or more than twice that of either route 80 or route 88. Because of this, and because the buses make numerous stops compared to a single commuter rail station, a commuter rail stop at Winter Hill would reduce total perceived origin to destination time for very few riders. The exceptions would be persons living close to the station and able to time their arrivals so as to minimize waiting time. Further analysis is needed for a specific demand estimate.

Adding a stop at Winter Hill would increase the running time for New Hampshire route trains by approximately 1.2 minutes including station dwell time. If all trains made this stop, exising riders would suffer a net travel time increase of 25,600 hours per year, equivalent to a cost of $76,800 using a time value of $3.00 per hour. This loss could be reduced if only selected trains were to stop at Winter Hill. A flag stop would produce time loss less than a scheduled stop, but trains would still have to slow down prepared to stop.

b. Chelsea Station. This proposal would consist of reopening the Chelsea station on the B&M Eastern Route. This station was located in the vicinity of Washington Avenue, and was closed in 1958. With good track, the scheduled running time from Chelsea Station to North Station would be 9 minutes.

At present, public transportation from downtown Chelsea to downtown Boston is provided by MBTA bus route 111 from Woodlawn to Haymarket Square, and by MBTA bus route 114 to Maverick Square where connection is made with the Blue Line to Boston. The scheduled running time from Bellingham Square in Chelsea to Haymarket Square in Boston via Route 111 is 17 minutes in the peak and 13 minutes during mid-day. Due to the more central location of Haymarket Square, a terminal there has a distribution time advantage of about 4 minutes compared to North Station. The total scheduled time from Bellingham Square to State station via Route 114 and the Blue Line is 21 minutes during the peak, including transfer time at Maverick.

Route 111 currently operates on headways of 4 to 5 minutes during the morning peak, 12 to 15 minutes during mid-day, and 7 minutes during the evening peak. If all commuter rail trains that will operate through Chelsea under the Spring 1976 schedule were to stop there, headway would average 17 minutes in the peak and 30 minutes off-peak. The greater frequency of service on Route 111 would cancel out the 4 minute advantage of commuter rail based only on running and distribution times, except for persons able to arrange their trip starting times in order to connect closely with specific trains at Chelsea. For trips starting anywhere other than downtown Chelsea, the bus would have a further advantage owing to its greater number of stops.

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